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ALFALFA AS A SOLE FEED FOR DAIRY CATTLE[1]

F. W. WOLL

Experiment Station, Davis, California

If one were to name the two most important new features of American agriculture during the past quarter of a century, they would be the general introduction of the silo and of alfalfa culture on our stock farms. The silo was first adopted in the eastern and central states in the eighties and gradually spread westward, while alfalfa first became an important pasture and hay crop in the far west in the seventies and eighties, and from there its culture gradually became common throughout the central and eastern states. The thirteenth United States census showed that the acreage in alfalfa in the western states in 1909 made up 27 per cent of the total acreage of hay and forage, and about 7 per cent for the whole country. In Utah, Arizona, Idaho and Colorado, alfalfa made up from 40 per cent to 70 per cent of the total area in hay crops, and in other mountainous and western states 20 per cent or more of the hay acreage was devoted to alfalfa.

It is especially on the irrigated lands of the western states that alfalfa assumes its greatest importance. It is the leading irrigated crop of our country, both as regards acreage and total value of the crop. Over 30 per cent of the irrigated area of the western United States was in alfalfa in 1909, the crop aggregating over fifty million dollars in value or 28 per cent of the total for irrigated crops, an increase of 5 per cent above the corresponding figure for the twelfth census.

The proper utilization of a crop of this magnitude becomes a matter of the greatest economic importance to the individual farmer and to the country at large. In the eastern and central

[1] Paper read at the annual meeting of the American Society of Animal Production at Ames, Iowa, December 28, 1917. Published by permission of the Director of California Agricultural Experiment Station.

states alfalfa is generally used as a part of the hay ration or as a soiling crop for dairy cattle and young stock, also to a smaller extent for other classes of farm animals—fattening steers, horses, sheep and swine. It is nearly always fed in connection with other roughage and with grain feeds, the greatest advantage derived from its use being that it will reduce the amount of concentrates, especially high-protein feeds, that stock require for a large production, as has been shown by investigations at the New Jersey and other experiment stations.[3] The experiments have established the fact that a considerable proportion of the concentrates in the rations for dairy cows may be replaced by alfalfa without an appreciable decrease in production; this will result in a lowering of the cost of the rations fed, since alfalfa is a farm-grown feed which where well established, will, as a general rule, produce larger amounts of feed materials per unit of land than any other forage crop with the exception of Indian corn. In ground form, alfalfa is also used as a partial substitute for mill feeds and other concentrates, especially in feeding swine and poultry. In no case, however, is alfalfa used as the sole feed for farm animals as a regular practice in the eastern United States, so far as known. This is a distinct western practice, and confined to the irrigated regions of the semi-arid west where alfalfa culture reaches its highest development. Here, as in the east, alfalfa is fed primarily to dairy cows, but other classes of farm stock, beef cattle, sheep and even hogs, likewise frequently receive nothing but alfalfa throughout the year, alfalfa pasture or green alfalfa during the growing season, and alfalfa hay in the winter. We are here chiefly concerned with this practice in so far as it relates to the feeding of dairy cows, and may say at the outset that no ill effects apparently result from this monotonous diet, as might be supposed. On the contrary, both from the standpoint of efficiency of nutrients supplied and economy of production, there seems to be no reason to condemn offhand the system of feeding. The fact that tens of thousands of dairy farmers in

[3] Reports 1888, p. 910; 1903, p. 396; Bulletins nos. 148, 174 and 204; Maryland Bulletin, no. 98; Tennessee Bulletin, xvii, no. 74; Kansas Bulletin, no. 125.

these western states have followed the method of exclusive alfalfa feeding as a fixed practice for years and years at once suggests that it can hardly be seriously at fault and cannot be pronounced either irrational or wasteful except on the basis of very careful clinching experimental evidence.

For the purpose of ascertaining the facts as to the value of alfalfa as the sole feed for dairy stock, an investigation was begun at the California Station about three and one-half years ago. A number of young dairy heifers have since that time been fed alfalfa only, up to freshening and during one or two lactation periods, under conditions that permitted control of the amounts of feed eaten, the rate of the growth of the animals, and their dairy production. At the same time, an equal number of animals, as nearly similar to the others as possible in age, breeding, type, and condition, have been fed according to the best dairy practice prevailing in the state, on mixed rations of alfalfa hay, silage, and a fair amount of concentrates. The investigation was begun in April, 1914, with six pure-bred dairy heifers, three of which were placed on alfalfa only, and the other three on mixed rations. Each lot consisted of one Holstein heifer and two Jersey heifers. The animals were about one and one-half years old at the beginning of the experiment and one year from freshening. All six heifers have now finished their second lactations and data are available for their production and feed consumption during the two periods.

In December, 1915, another group of six yearling calves, all high-grade Holsteins, were placed on a similar experiment, three of which have since been fed alfalfa only and the other three, mixed rations similar to those fed in the first group. Five of these heifers have now finished their first lactation,—three fed alfalfa only and two fed mixed rations. We have, therefore, at the present time records of 9 lactation periods in all for heifers receiving alfalfa, and 9 for heifers of similar age and breeding, fed rations of alfalfa hay, silage and mixtures of various concentrates, mainly rolled barley, dried beet pulp, cocoanut meal, and wheat bran. The following table will show the more important facts relating to individual heifers included in the experiments.

TABLE 1

Heifers included in experiment, 1914–1917

	BREED	BORN	PLACED ON TRIAL	INITIAL BODY WEIGHT	DATES OF CALVING	REMARKS
Group A				*pounds*		
Lot I, fed alfalfa only:						
Bess Fayne Concordia	H	June 1, 1913	April, 1914	617	November 11, 1915 December 29, 1916	
Jap's Rose	J	September 9, 1912	April, 1914	668	January 25, 1915 February 11, 1916 March 13, 1917	
Fancy Dolly Marigold 2d*	J	September 14, 1912	April, 1914	723		
Begonia's Adelaide 2d	J	March 2, 1913	March, 1915	807	May 15, 1915 April 22, 1916 May 11, 1917	
Lot II, fed mixed rations:						
Bess of Hopland 3d†	H	March 23, 1913	March, 1915	693	August 22, 1915 August 30, 1916	
Univ. La Polka Lady 2d	H	August 25, 1913	March, 1916	1200	March 18, 1916 April 26, 1917	
Mermaiden's Fern 2d	J	September 16, 1912	April, 1914	691	December 27, 1917 February 20, 1916 September 24, 1917	
Meridale Jap's Nora	J	October 21, 1912	April, 1914	631	January 22, 1915 February 21, 1916 April 5, 1917	
Group B						
Lot I, fed alfalfa only:						
Babette	Gr. H	November 22, 1914	December, 1915	626	February 7, 1917	
Marie	Gr. H	November 18, 1914	December, 1915	696	November 7, 1916	
Fairie	Gr. H	October 10, 1914	December, 1915	696	November 7, 1916 October 8, 1916	Aborted
Lot II, fed mixed rations:						
Paula	Gr. H	December 6, 1914	December, 1915	658	November 28, 1916 December 9, 1917	Calf dead‡
Gwendolin	Gr. H	October 12, 1914	December, 1915	704	February 2, 1917	
Duchess	Gr. H	November 20, 1914	December, 1915	666	November 24, 1916 November 10, 1917	Aborted Aborted

* Suffered from fractured joint, killed March, 1915; replaced by Begonia's Adelaide 2d.

† Sold October, 1916; replaced by University La Polka Lady 2d.

‡ Killed in removing it from the cow; a big, strong, normal calf.

The object of the present paper is to present briefly the more important results that have been obtained in the investigation up to the present time and to ascertain in how far these will throw light on the question of the value of exclusive alfalfa diet for dairy cows and its physiological effects on the body development and the dairy production of the animals.

The heifers were measured and weighed once a month during the first year. After freshening, they were weighed regularly once every week, and measurements were taken every two or three months. The following measurements were taken: (a) height of shoulders, (b) height of hips, (c) width of hips from outside of one hook bone to the outside of the other, (d) length of hips, from front of hip bone to rear of pin bone, (e) body length from extreme front of shoulder point to extreme rear of pin bone, (f) girth; the circumference of the barrel 1 to 2 inches back of the front legs.

Great care was exercised to always take the weights and measurements of the heifers under comparable conditions and with a similar fill. It has been our effort in the feeding and management of the animals on the experiment to give them all the feed they would eat with a keen appetite and to keep them as comfortable as the conditions would permit. All feeds were weighed out to the animals, and the milk produced was weighed and composite samples taken that were tested once a week. Chemical analyses were made of samples of all feeds used in the investigation, through the kind assistance of Prof. M. E. Jaffa, Chief of the Nutrition Laboratories at Berkeley, but the study of the metabolic processes involved in the alfalfa feeding was necessarily postponed until provisions for biochemical work can be made at the University Farm.

In studying the effects of the two feeding practices investigated, we shall give and discuss summary results only for the two groups of animals included in the experiments, but the data for the individual animals have been carefully scrutinized in interpreting the results. The influence of the two systems of feeding will be traced in the following order: the increase in body weight and in the body measurements taken throughout the investigation; the

influence on the calves dropped; the production of milk and butter fat during each lactation period, and the relation of the feed eaten to the dairy production.

A. Influence on gain in body weight and measurements. The average results obtained as regards gain in body weights for the two lots of heifers in groups A and B will be seen from the following table.

TABLE 2

Increase in body weight of heifers

	LOT I ALFALFA ONLY	LOT II MIXED RATIONS
	pounds	pounds
Group A:		
Average weight at beginning	702.0	672.0
Daily gain prior to freshening*	0.88	0.91
Daily gain for entire period†	0.36	0.40
Group B:		
Average weight at beginning	673.0	676.0
Daily gain prior to freshening‡	1.29	1.32
Daily gain for entire period§	0.65	0.79
Average for both groups:		
Daily gain prior to freshening	1.05	1.11
Daily gain for entire period	0.50	0.60

* 324 and 302 days, respectively.
† 1117 and 1054 days, respectively.
‡ 252 days.
§ 639 days.

Larger average daily gains were secured on the mixed rations than on alfalfa hay, in case of both groups of heifers, the former gaining 1.11 pounds on the average before freshening, against 1.05 pounds for the alfalfa heifers, and 0.60 pound during the entire period against 0.50 pound for the alfalfa heifers, an average difference of 0.10 pound, or 20 per cent in favor of the mixed diet. These results are rather striking, and indicate clearly a superior nutritive effect of the mixed rations, so far as gain in body weights goes.

Instead of figures for the actual measurements taken during the progress of the investigation, the percentage increase in corresponding measurements during the record period is given in

the table below. The average increase in measurements during the full period of the investigation for the two lots is given separately and also for both combined.

In the case of both lots somewhat higher figures were obtained for the percentage increase during the period before freshening, and during the first or the second lactation periods, for the

TABLE 3

Measurements of heifers, with percentage increase, in inches

	LOT A AVERAGE FOR 8 ANIMALS		LOT B AVERAGE FOR 6 ANIMALS		AVERAGE FOR BOTH LOTS	
	Alfalfa only	Mixed rations	Alfalfa only	Mixed rations	Alfalfa only	Mixed rations
Height of shoulders, inches	47.2	49.5	46.4	46.8	46.9	48.3
Per cent increase	5.0	4.0	11.0	13.0	8.0	8.0
Height of hips	47.8	49.3	47.4	47.7	47.6	48.6
Per cent increase	4.0	4.0	9.7	9.3	6.0	6.0
Width of hips	17.6	18.0	15.5	15.3	16.7	16.9
Per cent increase	21.0	17.0	34.0	37.0	26.0	26.0
Length of hips	18.6	19.0	16.5	16.5	17.7	17.9
Per cent increase	14.0	12.0	24.0	28.0	19.0	19.0
Body length	54.3	56.0	51.9	51.9	53.3	54.3
Per cent increase	16.0	16.0	19.0	22.0	17.0	18.0
Girth	63.6	67.7	61.7	61.3	62.8	64.9
Per cent increase	10.0	10.0	15.0	19.0	12.0	14.0
Length of period, days	846.0	820.0	640.0	640.0	758.0	743.0

heifers fed mixed rations than for the alfalfa heifers, but these differences disappear when longer periods or when summary data for both lots are considered, except for increase in body length and girth measure. While the evidence cannot be considered conclusive, the tendency is toward a slightly larger body development of the animals on the mixed rations than of those on alfalfa only.

The average increase in height of shoulders for the alfalfa heifers in group A was 2.53 inches and for lot II, 2.03 inches, while the measurement for width of hip increased 3.43 and 2.9 inches for lots I and II, respectively. The ratio of increase of the latter to the former measurements is, therefore, as 1 : 0.74 for the alfalfa heifers and 1 : 0.70 for those on mixed feed. The corresponding figures for group B were 3.75 and 3.95 inches for increase in height of shoulders and width of hips, respectively, for the alfalfa heifers, and 4.53 and 4.3 inches for lot II, or a ratio of width of hips to height of shoulders of 1: 0.83 and 1 : 0.92 for alfalfa and mixed diet, respectively.

It will be noted that the two systems of feeding studied in this investigation did not produce appreciable differences in the rate of increase in width of hips and body height. It is not to be assumed that the skeletal form and conformation of growing dairy heifers will change in a similar way as that of beef animals, but the results obtained by Waters in his investigation of the influence of nutrients upon the animal form[3] suggest that both systems of feeding studied produced normally developed animals in this investigation and that dairy heifers appear to make a somewhat more marked increase in width of hips in comparison with body heights than takes place in the case of well fed young beef cattle or even moderately fed steers making a daily gain in body weight of about 1½ pounds.

The investigations so far cover data for only eight and six animals for groups A and B, respectively, and it is hardly to be expected that individual characteristics largely determined by inheritance, like size, thriftiness and other factors aside from feed consumed, would be evenly balanced for two lots of such small numbers of animals. Hence, the effect of the character of the rations fed on the body development as shown by the different measurements taken, is not necessarily correctly expressed by their results so far obtained. There is, however, no occasion for doubting the correctness of the results showing the greater increase in length of body and girth measurements on mixed

[3] 30th Report of Soc. Prom. Agr. Sc., p. 70; see also Jr. Agric. Research, vol. xi, p. 383.

rations than alfalfa only. Nor can there be any doubt as to the effect of the rations on the increase in body weight of the animals during the period covered by the measurements, 25 months. The gains for the heifers of the different breeds in practically all cases were larger for those on mixed rations than for those on alfalfa only. The former gained 44 per cent and 75 per cent for groups A and B, respectively, and the latter 41 per cent and 62 per cent, a difference of 7 per cent in the averages for both groups (57 per cent vs. 50 per cent).

B. Influence on calves dropped. Twenty-six calves have been dropped by the heifers on the experiment to date, there being six Jersey calves, and seven pure-bred or grade Holstein calves in each group. The alfalfa heifers dropped six bull calves and seven heifers, and those on mixed diet dropped five bull calves and eight heifers. One heifer on alfalfa only aborted, one on mixed diet aborted twice, and two on alfalfa diet dropped dead calves. The University dairy herd has been relatively free from abortion up to the present time, and the showing for the alfalfa heifers in this respect is considerably worse than might be expected. There is no definite evidence of causal relation between the alfalfa diet and the appearance of abortion, however, although the belief that such a relation exists is held by many dairy farmers and might be accounted for by the effect of excessive protein feeding on the vitality of the animals.[4] The only study of this question known to the writer failed to show that abortion or sterility in dairy cattle is more common in regions where exclusive alfalfa feeding is practiced than where practically no alfalfa is fed to the cows; in fact, the evidence appeared to be the other way.[5]

The calves dropped by the alfalfa heifers weighed, on the average, 59.8 pounds at birth (range 33 to 83 pounds), and those dropped by heifers on mixed rations averaged 64.4 pounds (range 41 to 90 pounds), an increase of 8 per cent in the average birth weight of the latter calves. The calves dropped by the Jersey

[4] See e.g., Pacific Rural Press, September 19, 1914 and December 8, 1917; Kimball's Dairy Farmer, December 15, 1914 and February 1, 1915.

[5] California Experiment Station, report 1914–1915, p. 34.

heifers fed alfalfa weighed 43.2 pounds, against 45.7 pounds for calves dropped by the Jerseys on mixed rations, the corresponding weights for the Holstein calves being 76.3 pounds and 83.2 pounds. The calves dropped by the heifers on mixed diet were, therefore, uniformly heavier than those dropped by the alfalfa heifers. The available records are not sufficiently complete, and the number of animals raised not large enough, to show whether or not the heavier calves continued to have the advantage as they grew older, so far as body weight is concerned, but a good-sized thrifty calf is always considered an asset whether it is to be raised or vealed.

C. Influence on dairy production. Complete records of production and of feed consumption for twelve first lactation periods and for six second lactation periods have been completed by the heifers on the experiment up to the present time, one-half of each for the heifers fed alfalfa only and those fed mixed rations. The following table shows the average production for the record period for the two lots of heifers.

We note that the mixed rations have proved decidedly superior to alfalfa only in point of dairy production up to the present time. During the first lactation period the heifers on the mixed rations produced, on the average, 92.86 pounds more butter fat than those fed alfalfa only, an increase of 45 per cent, and during the second lactation period 65.66 pounds more butter fat was produced by the heifers fed mixed rations than by the alfalfa heifers, a difference of 23 per cent in favor of the former. The latter figure was doubtless considerably reduced through the failure of one heifer, University 2d, to make a satisfactory production during this period. For some reason or reasons not clearly understood, she began to drop off rapidly in milk production last July and August, and dried up the middle of October after a lactation of less than six months, making a production during the lactation period of only 167 pounds butter fat against 352 pounds during the first lactation. The feed was undoubtedly not a factor in the case, as there was no material difference in the method of feeding during the two periods.

TABLE 4

Production and feed consumption, 1914–1917

	LENGTH OF LACTATION PERIOD	YIELD PER LACTATION PERIOD			AVERAGE BODY WEIGHT	FEED CONSUMPTION				
		Milk	Butterfat	Fat		Alfalfa hay	Green alfalfa	Silage	Green corn	Grain feeds
Lot I, alfalfa only	*days*	*pounds*	*pounds*	*per cent*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
First lactation period:										
Fayne	364	8,854.0	265.28	2.99	1,267	9,079	6,065			
Jap	365	5,010.2	251.09	5.01	792	7,870	7,853			
Begonia 2d	277	2,670.1	121.44	4.55	861	5,864	7,883			
Maria	316	6,021.1	197.70	3.28	1,064	7,904	3,982			
Fairie	382	6,467.7	217.45	3.36	940	9,692	4,451			
Babette	305	5,435.5	172.20	3.17	1,017	7,312	4,234			
Average	335	5,743.1	204.19	3.56	1,007	7,954	5,745			
Second lactation period:										
Fayne	345	8,216.8	258.64	3.15	1,334	8,677	4,069			
Jap	368	5,221.3	301.76	5.78	891	9,402	5,956			
Begonia 2d	348	5,678.4	297.09	5.23	925	8,894	5,072			
Average	354	6,372.2	285.83	4.48	1,050	8,991	5,032			
Lot II, mixed rations										
First lactation period:										
Bess III	284	5,978.6	166.68	2.79	1,312	4,808	2,452	6,299	629	673
University II	366	9,907.0	352.62	3.56	1,169	6,285	3,055	7,692		2,881
Mermaiden II	399	7,070.1	346.63	4.91	818	5,232	7,509	5,958	1,214	2,238
Nora	368	6,548.0	337.21	5.15	877	4,818	7,458	5,381	934	2,590
Duchess	351	7,691.5	262.16	3.41	1,110	5,345	2,380	7,528		2,366
Paula	359	6,961.0	317.01	4.55	1,057	5,395	2,380	8.056	195	2,260
Average	355	7,359.4	297.05	4.04	1,057	5,314	4,206	6,819	495	2,168
Second lactation period:										
University II	176	4,702.4	167.39	3.56	1,448	3,200	2,422	2,535	175	1,122
Mermaiden II	363	10,136.7	519.86	5.13	909	6,659	3,055	8,611		3,955
Nora	368	7,419.7	367.23	4.95	1,037	5,901	3,055	7,586		2,786
Average	302	7,419.6	351.49	4.74	1,131	5,253	2,844	6,244	58	2,621

Average daily rations fed. The average daily rations fed both lots of heifers during the two lactation periods are shown in the following table, with their contents of dry matter and digestible components, the latter having been computed from the average chemical composition of the various feeding stuffs fed during the progress of the investigation, and from tables showing average coefficients of digestibility.

The average contents of dry matter in the alfalfa rations was 24.9 pounds and in the mixed rations 28.6 pounds, the nutritive ratios being 1 : 3.7 and 1 : 5.3 for the two rations, respectively. By reference to Table IV, it will be noted that the average daily production for the two lactation periods on alfalfa alone was 17.6 pounds of milk and 0.71 pound butter fat, and on the mixed rations 22.7 pounds milk and 1.00 pound butter fat. Each hundred pounds of dry matter supplied in the alfalfa rations, therefore, produced 70.7 pounds milk and 2.82 pounds butter fat, and in the mixed rations 79.4 pounds milk and 3.50 pounds butter fat, an improvement in the latter rations over the former of 12 per cent and 23 per cent in the production of milk and butter fat, respectively.

If the net energy values furnished in the two rations be calculated, the reason for the greater efficiency of the mixed rations is readily seen. Using the average values given in Armsby's "Nutrition of Farm Animals," Appendix, Table VII, it will be found that the alfalfa rations supplied 2.05 pounds of digestible true protein, and a net energy of 9.9 therms, against 2.08 pounds digestible true protein and 15.4 net energy values in the mixed rations. The amount of the production by the alfalfa heifers indicates that the difference in the nutritive effect of the two rations can hardly have been as great as that indicated by the energy values given, and it seems likely that the computed net energy value of the alfalfa ration is too low. According to the average production and body weights of the heifers on alfalfa only, their energy requirements would be approximately 10.7 therms, a figure which is still 4.7 therms (or 44 per cent) below the calculated net energy furnished in the mixed rations.

TABLE 5

Average rations fed and nutrients contained therein

AMOUNT OF FEED	DRY MATTER	DIGESTIBLE	
		Protein	Carbohydrates and fat
Alfalfa rations			
First lactation period:			
23.7 pounds alfalfa hay	20.7	2.54	9.39
17.2 pounds green alfalfa	3.8	0.46	1.70
	24.5	3.00	11.09
Second lactation period:			
25.4 pounds alfalfa hay	22.2	2.72	10.06
14.2 pounds green alfalfa	3.1	0.38	1.41
	25.3	3.10	11.47
Nutritive ratio			1 : 3.7
Mixed rations			
First lactation period:			
15.0 pounds alfalfa hay	13.1	1.61	5.94
11.8 pounds green alfalfa	2.6	0.32	1.17
19.2 pounds silage	5.0	0.21	3.17
1.4 pounds green corn	0.3	0.01	0.18
6.1 pounds concentrates	5.5	0.58	3.86
	26.5	2.73	14.32
Second lactation period:			
17.4 pounds alfalfa hay	15.2	1.86	6.89
9.4 pounds green alfalfa	2.1	0.25	0.93
20.7 pounds silage	5.4	0.23	3.42
8.7 pounds concentrates	7.9	0.83	5.50
	30.6	3.17	16.74
Nutritive ratio			1 : 5.3

To the dairyman and to the practical mind in general, the question naturally arises,—did the increased production obtained on the mixed rations more than pay for the higher feed cost of these rations? The answer will differ in different sections and

during different seasons, according to the price of feeds and products. Average California market prices for feeding stuffs for the six year period up to and including 1916 were as follows:

	per ton
Alfalfa hay	$10.50
Barley	29.00
Dried beet pulp	24.00
Cocoanut meal	27.00
Wheat bran	27.00

Taking average feed prices like these as a basis for calculations,[6] we find that the alfalfa rations cost $56.34 and $61.49 for the first and second lactations, respectively, the corresponding figures for the mixed rations being $84.51 and $87.71, an increase in the average feed cost of $28.17 for the first lactation period and of $26.22 for the second lactation period. The increase in average production secured, leaving out of consideration the greater value of the calves dropped by the heifers on the mixed rations, and the larger amount of skim milk furnished by these heifers, was in round numbers 93 and 66 pounds of butter fat, for the first and second lactation periods, respectively, or an average cost of 33 cents and 25 cents a pound of increase in butter fat. These are average and below average figures, respectively, for butter fat during the period for which the cost of the ration was estimated. It would, therefore, seem that it is about an even break in the economy of the two systems of feeding considering average market prices for feeds that prevailed up to the current year. At war prices, the alfalfa rations will have a decided advantage, as the increase in cost has so far been proportionately less for this feed than for concentrates. In years past, the dairy farmers in our state have been accustomed to receiving or paying $8.00 a ton for alfalfa in the stack. Evidently, at this figure and with prices of grain and other common concentrates at $20.00 to $30.00 a ton, there is no direct gain to be expected by changing from clear alfalfa to a mixed ration.

Whether or not other factors, like the influence of the rations fed on the condition of the cows themselves or on their calves,

[6] The exact prices assumed are: alfalfa hay, $12.00; green alfalfa or green corn, $3.00 per ton; corn silage, $4.00 per ton, and concentrates $30.00 per ton.

would render it advisable to give a variety of feeds, cannot be definitely stated from the results now available, but the evidence would not probably be sufficiently strong to commend this method of feeding to the judgment of the average dairyman. As a matter of general interest, it may be said that exclusive alfalfa-feeding for dairy cows has frequently produced excellent results in the past, both in the case of individual cows and whole herds; for example, one herd of 23 cows in one of the California Cow-Testing Associations last year averaged 410 pounds of butter fat on no other feed than alfalfa from the beginning of the year to the end. The results to which this investigation has led so far show clearly, however, that the production of good dairy-bred heifers can be appreciably increased by feeding a variety of feeds, and that the body development of both calves and young dairy stock is, in general, improved by this system of feeding. With the results of the investigation before him, a dairyman can readily decide whether or not he will be justified in feeding rations ontaining feeds from different plant sources and including expensive concentrates under the special conditions under which he is operating his dairy.

STUDIES ON THE UNIFORMITY OF HEATING IN THE FINAL PACKAGE METHOD OF PASTEURIZATION

B. W. HAMMER AND A. J. HAUSER

Department of Dairying, Iowa State College, Ames, Iowa

INTRODUCTION

In the long series of studies and experiments that have led to the evolution of the common methods of pasteurization in use today, the necessity for the uniform heating of a given lot of milk has been widely considered. The main reason for uniform heating during pasteurization is to insure sufficient heat to destroy the pathogenic organisms and a satisfactory percentage of the total bacteria in all portions of the milk without overheating any part of it, so that a small volume of milk insufficiently heated may not recontaminate the whole lot when distributed through it. The present paper presents the results obtained in a study of the uniformity of heating with the final package method of pasteurization as carried out in the market milk room of the Iowa State College on the "special" milk put out on the milk route.

METHODS USED

The method of final package pasteurization employed with the milk studied consists of immersing the bottles sealed with metal caps in cases 3 tiers high in a vat of water at a temperature not above 110°F. The temperature of the water is then rapidly increased by means of a steam heater placed along one side and under an iron grate on which the cases rest. When the temperature of the water reaches about 148°F. the steam is shut off and is turned on again only if it is necessary in order to bring the temperature of the milk (which is determined with a bottle thermometer) to 140°F. or to maintain it at at least this temperature during the holding period. In many instances, under these circumstances, the temperature of the milk rises slightly above

140°F. as is evident from the data later presented. After the heating period, the water in the vat is cooled by a spray of cold water entering throught a perforated pipe underneath the grate; when the milk is cooled to about 70°F., the cases are removed to the refrigerator and iced.

The milk studied was pasteurized in regular runs made with the apparatus described above but sterilized bottles and caps were used. As soon as the cooling with water was completed, the bottles to be studied were packed in ice and brought to the laboratory where the tests were begun as soon as possible.

The medium used for the determination of the number of bacteria was a beef extract agar and the plates were incubated at 37°C. for forty-eight hours before counting. In all but a very few instances where one of the plates was lost, the results represent the average of two plates.

The creaming ability was determined by the method used previously in the dairy section of the Iowa Agricultural Experiment Station. It consists of putting a nine inch layer of milk in a Nessler tube by filling the tube up to a line filed on it, standing the tube in ice water for about twenty-four hours and then measuring the depth of the cream layer and expressing the result in sixteenths of an inch.[1] In the tests of the creaming ability of the pasteurized milk usually only one determination was made from each bottle, while with the raw milk, as a rule, four tests were made, one from each of four bottles representing the raw milk, and the average taken.

RESULTS OBTAINED

Data showing the importance of uniform heating

In order to illustrate the necessity of considering the uniformity of heating with the final package method of pasteurization, some of the results secured with one of the newer methods devised for the heating of bottled milk are presented in table 1. In the

[1] See Iowa Agr. Expt. Sta. Res. Bulletin no. 31.

TABLE 1

Variations in bacterial content and creaming ability in bottles of milk pasteurized in the same run by one of the final package methods

	RUN 1		RUN 2		RUN 3		RUN 4		RUN 5		RUN 6		RUN 7	
	Bacteria per cubic centimeter	Cream layer	Bacteria per cubic centimeter	Cream layer	Bacteria per cubic centimeter	Cream layer	Bacteria per cubic centimeter	Cream layer	Bacteria per cubic centimeter	Cream layer	Bacteria per cubic centimeter	Cream layer	Bacteria per cubic centimeter	Cream layer
Raw milk	131,000	25.5	900,000	23.5	1,800,000	23.0	13,000	24.5	13,750	24.0	158,500	18.5	323,000	25.0
Bottle 1, Past. milk	570	18.0	5,400	15.5	180	14.0	650	21.5	15	10.0	45	9.0	55	18.5
Bottle 2, Past. milk	800	17.0	3,500	12.0	160	14.0	110	10.0	40	12.0	25	8.5	640	18.5
Bottle 3, Past. milk	950	17.5	190	9.0	50	Indistinct	50	9.5	15	11.0	30	7.0	430	17.0
Bottle 4, Past. milk	2,005	25.0	35,000	19.5	105	19.5	580	21.5	65	16.0	50	8.5	890	20.0
Bottle 5, Past. milk	2,115	21.0	24,000	22.5	455	18.0	620	21.5	80	21.5	55	13.0	1,120	21.0
Bottle 6, Past. milk	1,110	22.0	2,650	21.0	200	14.0	55	14.5	70	19.5	35	10.5	1,040	19.0
Bottle 7, Past. milk	3,115	24.5	60,000	22.0	440	22.0	690	21.0	175	22.0	110	12.0	1,295	21.0
Bottle 8, Past. milk	4,500	24.5	18,000	21.0	390	18.5	390	21.5	145	22.0	405	16.5	2,060	22.5
Bottle 9, Past. milk	3,460	24.0	19,000	22.0	380	20.5	60	16.0	75	17.0	55	12.0	940	21.0

apparatus[2] used the bottles were pasteurized in the cases which were piled three deep; bottles 1, 2, and 3 were from the top case, bottles 4, 5, and 6 were from the middle case and bottles 7, 8 and 9 were from the bottom case.

From table 1 it is evident that, with the method employed, wide variations existed in the bacterial content and creaming ability of the different bottles of milk pasteurized in the same run. As would be expected there is a general relationship between the effect on the bacterial content and the effect on the creaming ability, a low bacterial content usually accompanying a shallow cream layer. This relationship is by no means always close, however, in the data presented, and is presumably due, in part at least, to the unavoidable errors made in the determination of the numbers of bacteria; the errors made in the determination of the creaming ability are not large if the agreement of duplicate determinations is accepted as a basis for judging accuracy. The data illustrate clearly that, with the apparatus used, big differences would occur in the cream layers on bottles of milk pasteurized in the same run, which would of course be very undesirable from a commercial standpoint, and that considerable differences in the bacterial content of the bottles, with the possibility of incomplete destruction of pathogens in some, might occur.

Data secured on the final package method used at the Iowa State College

The data secured on the method of final package pasteurization employed in the market milk room of the Iowa State College have been divided into two parts on the basis of the number of bottles examined from each run.

The results obtained on ten runs in which one bottle was examined from each of the top, middle and bottom tiers are presented in table 2; the exposure used, as determined by a bottle thermometer in one of the bottles held near the top, is also shown.

[2] The method will not be described in detail since the results were secured on a small experimental pasteurizer; while there is no reason to believe that different results will be obtained with a larger machine, it seems best to withhold complete information until the method has been tried on a larger scale.

TABLE 2

Variations in bacterial content and creaming ability in bottles of milk pasteurized in the same run by the final package method when the cases are immersed in a vat of water

RUN NO.	RAW		BOTTLE FROM TOP TIER		BOTTLE FROM MIDDLE TIER		BOTTLE FROM BOTTOM TIER		EXPOSURE AS DETERMINED BY BOTTLE THERMOMETER IN A BOTTLE NEAR THE SURFACE
	Bacteria per cubic centimeter	Cream layer	Bacteria per cubic centimeter	Cream layer	Bacteria per cubic centimeter	Cream layer	Bacteria per cubic centimeter	Cream layer	
1	45,000	21.5	5	19.0	5	19.0	35	19.0	140°–143°F. for 25 minutes.
2			1,420	18.5	280	18.0	240	18.0	140°–143°F. for 25 minutes.
3	13,750	24.0	30	20.0	40	20.5	65	21.0	142°F. for 20 minutes.
4	158,500	18.5	70	16.5	205	16.5	300	17.0	142°F. for 20 minutes.
5	108,000	20.0	10	20.0	15	20.0	35	20.0	140°F. for 20 minutes.
6	540,000		7,200	18.0	8,400	19.0	9,000	19.5	140°–141°F. for 20 minutes.
7	8,400,000	31.0	15,000	19.0	16,800	19.0	18,000	21.0	140°–142°F. for 20 minutes.
8	323,000	25.0	705	20.5	2,065	21.0	1,700	21.0	140°–143°F. for 20 minutes.
9	135,500	25.5	420	24.0	360	24.0	360	24.0	140°F. for 20 minutes.
10	14,400,000	19.0	10,000	12.0	12,000	12.0	13,000	12.5	140°–142°F. for 20 minutes.
Total			34,860	188.0	40,170	189.0	42,735	193.0	

Results of bacterial counts

The bacterial counts secured on the bottles from a given run show considerable uniformity but it is evident that in general, although by no means constantly, the lowest count was secured on the bottle from the top tier of cases and the highest count on the bottle from the bottom tier. The greatest variation from this general relationship occurred in run 2 where the count on the bottle from the top tier is considerably higher on the percentage basis than the counts secured on the other bottles; runs 8 and 9 also show variations from the general relationship but here the differences are so small that they may easily be due to experimental error. The sums of the three columns showing the bacterial counts after pasteurization can be used to show the general relationship. The sum of the counts secured on the bottles from the top tier is 34,860, that of the counts secured on the bottles from the middle tier is 40,170 and that of the counts secured on the bottles from the bottom tier is 42,735; as would be expected the same relationship is shown here as is shown in the majority of the runs.

Results of creaming ability tests

The data secured on the cream layers show that there was a great deal of uniformity in the creaming ability of the three bottles examined from each run; the differences were entirely too small to have been noticeable if the milk had been allowed to cream in the bottles. In three runs (nos. 1, 5, and 9), the values for the cream layers are the same for the three bottles in each run. Since the differences in the creaming ability of the three bottles in each run are so small, the general relationship can best be seen by comparing the sum of the cream layers of the bottles from the top tier with the sums for the bottles from the middle tier and the bottles from the bottom tier. The values are 188.0 for the bottles from the top tier, 189.0 for the bottles from the middle tier and 193.0 for the bottles from the bottom tier; these sums show that in general there was the shallowest cream layers in the bottles from the top tier, while the deepest cream layers were in the bottles

from the lowest tier. As already stated, however, the variations are entirely too small to be of any significance.

Both the bacterial counts and the cream layers indicate that the heating near the surface of the vat is slightly greater than at the bottom. If the data for each run are considered, it is evident that there is a general agreement between a lower bacterial count and a shallower cream layer, although variations from the general relationship are common; these variations are to be expected where the differences between both the bacterial counts and the cream layers secured on a given run are so small.

From table 2 it is evident that the exposures used decreased the creaming ability of the milk although in the most of the runs the decrease was not very serious. The ten runs also show that higher counts after pasteurization were secured with the milk having the higher initial count.

The results obtained on nineteen additional runs (nos. 11–29 inclusive) in which two bottles from different cases in the same tier were examined, are shown in table 3. The pasteurization exposures were not recorded but were essentially the same as those recorded in table 2.

Results of bacterial counts

As a rule, the bacterial counts secured on the 6 bottles from a given run show a reasonable agreement. However, considerable differences on the percentage basis between bottles from the same tier did occur and in a few instances (e.g., run 17) big variations were encountered. When bottles from different tiers are considered, the variations between counts are greater than when the bottles from the same tier are considered. The general trend of the results can best be seen by considering the sums of the bacterial counts on the heated milk in each column in table 3; the 19 counts on bottle 1, top tier, total 70,935; those on bottle 2, top tier, total 74,365; those on bottle 1, middle tier, total 86,555; those on bottle 2, middle tier, total 82,655; those on bottle 1, bottom tier, total 109,120 and those on bottle 2, bottom tier, total 88,650. The two lowest totals are those for the top tier

TABLE 3

Variations in bacterial content and creaming ability in bottles of milk pasteurized in the same run by the final package method when the cases are immersed in a vat of water

RUN NO.	RAW		BOTTLES FROM TOP TIER				BOTTLES FROM MIDDLE TIER				BOTTLES FROM BOTTOM TIER			
			Bottle 1		Bottle 2		Bottle 1		Bottle 2		Bottle 1		Bottle 2	
	Bacteria per cubic centimeter	Cream layer	Bacteria per cubic centimeter	Cream layer	Bacteria per cubic centimeter	Cream layer	Bacteria per cubic centimeter	Cream layer	Bacteria per cubic centimeter	Cream layer	Bacteria per cubic centimeter	Cream layer	Bacteria per cubic centimeter	Cream layer
11	2,400,000	23.0	20,000	16.5	17,000	16.0	850	17.5	1,000	17.0	10,700	20.0	5,050	20.5
12	9,600,000		12,650	22.5	10,100	20.5	34,500	29.0	25,300	28.5	45,500	31.0	40,000	30.0
13	185,000	22.0	275	19.5	190	19.0	220	20.0	375	20.0	450	20.5	335	20.5
14	53,500	22.0	345	16.0	240	15.0	630	17.5	795	16.5	1,120	18.0	870	17.5
15	19,300	21.5	40	14.0	35	14.0	60	16.5	40	16.5	100	17.5	55	17.0
16	945,000		11,500	17.5	9,600	18.0	8,500	18.0	10,500	16.5	17,000	17.5	12,200	17.0
17	4,130,000	21.5	15,700	20.0	24,400	19.0	23,350	20.0	31,600	20.0	18,500	20.0	13,000	20.5
18	410,000	23.0	150	16.5	245	16.0	325	19.5	400	20.0	440	20.5	455	21.5
19	7,500	26.0	160	22.0	425	20.5	170	22.0	105	22.0	195	21.5	260	21.5
20	6,550*	20.5	200	21.5	70	21.0	195	21.5	85	20.5	265	21.5	200	21.5
21	61,000	18.0	30	14.5	50	14.5	55	15.0	125	16.0	55	14.5	50	15.0
22	1,200,000	19.0	5,960	13.5	6,480	13.0	12,600	15.0	8,320	15.0	9,140	16.0	9,840	16.0
23	375,000		390	17.0	275	16.5	300	17.5	320	17.5	320	17.0	370	17.5
24	102,500*		220	13.5	175	11.5	780	14.0	935	13.0	1,665	13.5	1,965	12.5
25	12,550	20.0	65	15.0	135	16.0	125	17.0	75	16.0	130	17.0	80	15.5
26	14,000		250	16.0	320	14.5	220	17.0	270	16.0	230	18.0	335	18.0
27	88,500*	23.5	2,335	20.5	3,985	21.5	2,830	20.5	1,740	21.0	2,530	21.5	2,655	21.5
28	179,875*		570	21.0	565	20.5	775	22.0	610	22.0	680	23.5	875	23.5
29	7,963*	24.0	95	17.5	75	15.0	70	18.0	60	19.5	100	19.5	55	21.0
Totals			70,935	334.5	74,365	322.0	86,555	357.5	82,655	353.5	109,120	368.5	88,650	368.0

* Average of four determinations.

while the two highest are those for the bottom tier and the general relationship shown is accordingly the same as that shown by the data presented in table 2. The differences in the bacterial counts secured on the bottles pasteurized in the same run are comparatively small, however, and suggest that the variations in the extent of the heating must be quite small.

Results of creaming ability tests

The data secured on the cream layers show only very small differences when bottles from the same tier are considered. When different tiers from the same run are considered the variations were considerably more, and in general the shallowest cream layers were secured from bottles coming from the top tier and the deepest cream layers from bottles coming from the bottom tier. The sums of the cream layers in each column show the general trend of the results. The sum for bottle 1, top tier, is 334.5; that for bottle 2, top tier, is 322.0; that for bottle 1, middle tier, is 357.5; that for bottle 2, middle tier, is 353.5; that for bottle 1, bottom tier, is 368.5 while that for bottle 2, bottom tier is 368.0. These sums show a very good agreement between bottles 1 and 2 of each tier and in general show a slight increase in the depth of the cream layer with an increase in the distance from the surface of the vat. The differences in the cream layers secured on bottles from a given run indicate, however, that in general the heating must be fairly uniform.

The results for run 12 show an unusual situation in that the differences between the cream layers secured on the different tiers are much greater than is usually the case and accompanying this are differences in the bacterial counts secured on the different tiers that are greater than in any other run. This indicates a reasonably close agreement between the effect on the creaming ability and the effect on the bacterial count. This same relationship is shown in other instances but not as definitely as in run 12.

The agreement of counts made on the same milk

In order to get definite information as to the variations in the bacterial counts that could be attributed to experimental error under the conditions prevailing, counts were run on four bottles of the raw milk in each of five of the runs dealt with in table 3. The results of the counts are given in table 4 as is also the average of each set and the per cent variation of each count from the average.

From table 4, it will be seen that in run 20 the variations ranged from 2 to 18 per cent with 3 counts less than the average

TABLE 4

Variations in the bacterial counts secured on bottles of the same lots of raw milk

	RUN 20		RUN 24		RUN 27		RUN 28		RUN 29	
	Bacterial counts	Per cent variation from average	Bacterial counts	Per cent variation from average	Bacterial counts	Per cent variation from average	Bacterial counts	Per cent variation from average	Bacterial counts	Per cent variation from average
Average.....	6,550		102,500		88,500		179,875		7,963	
Determination 1..	7,700	+18	93,500	− 9	81,500	− 8	192,500	+7	7,450	−6
Determination 2..	6,450	− 2	104,000	+ 1	96,500	+ 9	168,000	−7	8,700	+9
Determination 3..	5,900	−10	101,500	− 1	100,000	+13	181,000	+1	8,450	+6
Determination 4..	6,150	− 6	111,000	+ 8	76,000	−14	178,000	−1	7,250	−9

and 1 above; in run 24 the range in the variations was from 1 to 9 per cent with 2 above and 2 below the average; run 27 showed variations from 8 to 14 per cent with 2 above the average and 2 below; run 28 showed variations from 1 to 7 per cent with 2 above the average and 2 below, and in run 29 the variations ranged from 6 to 9 per cent with 2 above the average and 2 below the average. The count showing the greatest variation from the average showed a variation of 18 per cent. From the results presented it seems certain that the differences shown in tables 1, 2, and 3 in the bacterial counts secured on bottles from the same run represent real differences and cannot be ascribed to experimental error.

General consideration of the results

The results secured and presented in tables 2 and 3 indicate that, with the method of final package pasteurization under consideration, the different bottles pasteurized in a given run are heated quite uniformly and that, with this method, the variations in the heating are in general of no importance from the standpoint of the bacterial counts or the creaming abilities. The data secured suggest that there is a tendency for the bottles at the top of the vat to be heated the most and those at the bottom to be heated the least; this tendency is shown in both the slightly lower bacterial counts and the slightly shallower cream layers in the bottles of milk held nearest the surface. The differences between the bottles at the surface and those at the bottom is not at all a constant one and in some cases the differences are considerable; these differences may be influenced by the rate of heating the water or by some other such factor. The cause for the greater heating at the surface is presumably the tendency of the heated water to rise and thus to heat the surface bottles more than those beneath.

From the data presented it seems that there is ordinarily a small variation in both the bacterial content and the creaming ability of bottles of milk pasteurized in the same tier, but these variations are too small to be of any significance from a practical standpoint. They may be due in part to differences in the thickness of the bottle wall which would, of course, affect the rate of heat transmission from the surrounding water to the contained milk.

The reasonably close agreement between the effect of heat on the bacterial count and on the creaming ability as shown throughout tables 1, 2, and 3 suggests that tests of the creaming ability afford a satisfactory and simple method of determining the uniformity of heating in the final package method of pasteurization. By determining the cream layer thrown up by a number of bottles of milk pasteurized in a given run the uniformity or lack of uniformity in heating can quite readily be told. The determination of the cream layer is much less time consuming

than the determination of the number of bacteria present, less apparatus is required, and the results are more quickly secured. Furthermore, creaming ability tests can be used under the conditions prevailing in small plants where bacterial counts can usually be made only with extreme difficulty. The creaming ability should be determined by means of tubes such as Nessler tubes rather than by allowing the bottles of milk to stand since slight differences in the creaming ability can be much more readily detected by the use of tubes.

Significance of uniform heating with the final package method of pasteurization

With the method of final package pasteurization, the uniform heating of the milk assumes a somewhat different significance than with the usual holding or continuous methods. An insufficiently heated bottle may be a source of great danger and this is particularly serious because of the rather widespread belief that milk pasteurized by the final package method is certainly safe since there is no opportunity for contamination after the heating, and since the heating is supposed to destroy all the pathogens ordinarily present. On the other hand, however, one or more improperly heated bottles will not contaminate the entire run of milk as will a small portion of insufficiently heated milk with other methods of pasteurization. Where the milk of a given run is not mixed after heating as is the case with the final package method, there is no equalization of the creaming ability and of the heated flavor and as a result where there is a lack of uniformity in heating, big differences in the extent of the heated flavors and in the cream layers developed are observed. The problems of heated flavor and creaming ability accordingly assume a much greater importance, from the standpoint of the uniform heating of the milk, with the final package method than with the other methods of pasteurization and may be of a great deal of significance under commerical conditions.

CONCLUSIONS

1. The problem of the uniform heating of the milk is deserving of careful consideration with the final package method of pasteurization as well as with the other methods.

2. Great variations occurred in the extent of the heating of different bottles in the same run with a small experimental final package pasteurizer.

3. With the method of final package pasteurization in use at the Iowa State College Market Milk Room which consists of heating in a vat of water, only small variations occurred in the bacterial content and the creaming ability of different bottles from the same run. There was, however, a general tendency for the bottles at the surface to show the lowest bacterial content and creaming ability; the differences in general were, however, too small to be of practical significance.

4. The determination of the creaming ability by means of tubes of milk allowed to stand affords a simpler and quicker method of detecting the uniformity or lack of uniformity in heating with the final package method than does the determination of the bacterial counts.

THE POSSIBILITY OF INCREASING MILK AND BUTTERFAT PRODUCTION BY THE ADMINISTRATION OF DRUGS[1]

ANDREW C. McCANDLISH

Dairy Husbandry Section, Iowa Station, Ames, Iowa

The secretion of milk, being an extremely complicated process, is subject to many variations and though some of the factors influencing it are understood, many others are unappreciated or even unknown. For a long time it has been believed that many drugs have the power of influencing milk secretion and, owing to the popularity of official and semi-official testing of dairy cows, this is of special interest at the present time.

Within recent years some men undoubtedly have tried to influence favorably the production of their test cows by means of drugs and consequently when a cow makes an exceptional record there are many ready to affirm that drugs must have been used to bring about the phenomenal results. Consequently some breed associations prohibit the use of such substances with cows on test and it is not uncommon for association officials to make public denial of the use of drugs in connection with the making of certain records.

The present work was undertaken, with the coöperation of Dr. H. D. Bergman, of the Department of Physiology and Pharmacology, of the Veterinary Division of the Iowa State College, to test the validity of some of these statements regarding the use of drugs with milk-producing cows.

The knowledge of the effect of drugs on the active mammary gland is very incomplete and, though admitting the fact that drugs might under certain circumstances alter milk secretion, the veterinary profession does not recognize any direct galactagogues.

[1] A paper presented at the annual meeting of the American Society of Animal Production, Ames, Iowa, December, 1917.

No attention will be given here to experimentation with the human subject, the goat, or mammalia other than the cow, for the simple reason that though much valuable work has been done with these subjects the results need not necessarily be directly applicable to the cow as there may be certain generic differences in physiological activity, and it is known that in some cases, e.g., with the human subject, variations in milk production can be brought about much more readily than in the case of the cow.

There are various ways in which the activity of the udder might be influenced by drug action and amongst these are the following:

1. Direct action of the drug on the protoplasm of the secretory cells.
2. Influencing the secretory nerve terminations.
3. Vasomotor influences with a resulting change in the amount of blood supplied to the active mammary tissue.
4. Variation in the heart's action with a possible influence on circulatory conditions.
5. Action on the digestive system, thus influencing the amount of nutrients available for utilization by the secretory cells.

As these actions may be brought about separately or in almost any combination and in varying degrees of intensity, it is seen that the problem of the influence of drugs on milk secretion is a complicated one and the fact that individual cows may vary somewhat in degree of susceptibility to drug action increases the complexity.

The problem is here treated with the view of determining the possibility of influencing the production of healthy cows and more particularly the percentage of fat in the milk, and thus ultimately the total yield of fat. In conducting this work the one or two day tests of the dairy cattle breed associations were kept in mind because it is not only in such tests that there would be the greatest opportunity and temptation to use drugs, but also fairly well recognized that a slight increase in production might be maintained for a few days by the use of drugs and yet be only temporary; and in addition continued drug administration would be more readily detected.

There is a long list of substances popularly reputed to have galactagogic effects—amongst these are the aromatics, fennel, anise, caraway, juniper berries, coriander, dill, pimpinella, calamus; the bitter stomachics, sulphur, the neutral salts, the antimony preparations, and many others—but distinction must be made between the use of drugs based on a knowledge of their physiological action and the use of those indicated by empirical teachings. The popular milk powders are compounded largely from the constituents just stated.

In this piece of work the drugs used include alcohol, castor oil, pituitrin, pilocarpine, physostigmine, aloes, calomel, nux vomica, Epsom salts and common salt, and these have been chosen in view of the fact that a knowledge of their physiological action would seem to indicate some possibility of their either directly or indirectly influencing the mammary gland. Some of the principal physiological effects noted upon the administration of these drugs are as follows:

Alcohol. When introduced into the general circulation alcohol produces a narcotic effect especially on the nervous tissues. It diminishes the efficiency of vital organs like the heart, blood-vessels and blood and their nervous mechanisms, with, in certain cases, an initial but transient stimulation. It interferes with body metabolism and especially with body oxidation. In addition, alcohol removes water from the tissues in large quantities, producing diuresis. This abstraction of water creates a physiological thirst which may result in a great craving for water or it may induce nausea with a consequent distaste for water.

Castor oil. Castor oil is not absorbed from the intestinal tract and in itself is not purgative. It is broken down in the alimentary canal with the production of ricinoleic acid and other substances which cause great irritation and subsequently bring about purging which not only carries off nutrients that might otherwise be utilized but also produces general depression.

Pituitrin. The extract of the pituitary body, one of the ductless glands, brings about a rise in blood pressure probably due to vaso-constriction and simultaneous heart stimulation though it has been found that the heart may not always be stimulated and

sometimes may even be weakened. It brings about an increase in urine elimination, perhaps by direct action on the renal epithelium, and it also stimulates the uterus and bladder.

Pilocarpine. The terminations of what are pharmacologically known as the autonomous nerves—the nerves serving the involuntary muscles but not passing through the sympathetic system —are stimulated by pilocarpine and consequently its adminis ration may result in slowing of the heart, constriction of the bronchi, increased peristalsis, and hyper-secretion of the gastric, intestinal, salivary and sweat glands.

Physostigmine. Eserine or physostigmine acts very similarly to pilocarpine with the exception that it does not influence the secretions as markedly but stimulates peristalsis to a greater extent.

Aloes. The purgative action of aloes is due to the active principle aloin which stimulates peristalsis of the large intestine but does not influence the intestinal secretions. It is absorbed from the large intestine and is eliminated by way of the bowels, kidneys, and mammary gland. It sometimes causes diuresis; induces reflex irritation of the female pelvic organs, is an emmenagogue; and may be abortifacient.

Calomel. This is changed in the intestine to the grey oxide of mercury which has an irritating effect and so produces purging. Its action is chiefly on the small intestine and it is not absorbed. It is supposed to be a chologogue, the fact that it flushes out the small intestine probably inducing the bile to follow along though there is no direct action on the liver. Mercury, being a local irritant, may lead to increased secretion of the glands if the dose is sufficient to irritate without destroying the glandular protoplasm.

Nux vomica. When taken internally nux vomica, being a bitter stomachic, increases appetite and stimulates the secretion of the digestive juices. Therapeutic doses, after absorption, stimulate the great medullary centers, respiratory, vasomotor, and cardoinhibitory, with a consequent rise in blood pressure and slowing of the heart. It is frequently given as a "tonic" but its only influence on nutrition is to send more blood to the tissues.

Epsom salts. The purgative action of magnesium sulphate is due to the fact that it not only prevents the absorption of water from the intestine but also abstracts water from the intestinal wall into the lumen.

Common salt. Sodium chloride is absorbed and does not cause purging, except when in large quantities, though it produces diuresis by abstracting water from the tissues.

PREVIOUS WORK

The study of the action of galactagogues on the human subject, goats and small laboratory animals has been fairly extensive, while their influence on the milk production of cows has received little attention.

Pituitrin. Even in the case of pituitrin, the most studied of all supposed galactogogues, very little work has been done with bovines. In endeavoring to find if there were any commercial benefits to be derived from treating cows with pituitrin, Gavin (1) used three methods for adminstering pituitary extract—by the mouth, subcutaneously, and intravenously—and he came to the conclusion that no increase in the daily milk yield or in the percentage of fat in the milk was obtained as a result of pituitrin administration. Hill and Simpson (2), on the other hand, found that the percentage of fat in cow's milk could be increased by administering pituitary extract intravenously but the yield of fat subsequently made a compensatory decrease.

Pilocarpine and physostigmine. According to Feser (3) the milk yield of cows is slightly increased by the injection of pilocarpine and eserine, while Frohner (4) got negative results with pilocarpine.

Aloes. It was found by Lanzoni (5) that the fat percentage in cow's milk was decreased by the administration of aloes. . .

Epsom salts. Lanzoni (5) found that the fat in cow's milk was increased after the administration of magnesium sulphate.

PLAN OF EXPERIMENT

The experimental work on which this paper is based was conducted in two parts, the preliminary series of experiments being carried out with only one cow, while in the second series three cows were used.

TABLE 1

Animals used

	Series			
	I	II		
Cow number	262	207	243	262
Breed	Grade Guernsey	Grade Holstein	Ayrshire	Grade Guernsey
Age, years	2.0	4.2	3.1	2.7
Weight, pounds	800	1280	840	900
Fresh, days	10	86	155	242
Previous lactations	0	2	0	0

The animals were all young, in good milking condition and free from derangements of health. They were kept open throughout the experiments.

The rations fed were practical ones suited to the needs of the animals and were such that no appreciable changes in the live weights of the animals took place.

In the first series the experimental periods were not always of the same length but in the second series the experimental periods were always of two days duration, while the check periods were each of four or five days. The experimental period was always taken as beginning with the milking next following the administration of the drug, the influence of which was being studied, and there were check periods before and after each experimental period.

The drugs were given either orally or subcutaneously.

TABLE 2

Administration of drugs

DRUG	SERIES	DOSAGE AND METHOD OF ADMINISTRATION
Alcohol	I	3 ounces of grain alcohol in a quart of water twice daily for two days
	II	Dose increased to 4 ounces
Castor oil	II	16 ounces in evening and 8 ounces in morning daily for two days
Pituitrin	I	2 drams of pituitary extract subcutaneously twice daily for four days
	II	Pituitary extract subcutaneously in doses of 1 dram in evening, 1 dram in morning and 2 drams at noon daily for two days
Pilocarpine and physostigmine	I	2 subcutaneous injections ½ hour apart in the morning and the same in the evening, daily for four days. Each dose contained 1 grain pilocarpine hydrochloride and ½ grain physostigmine benzoate
	II	2 grains pilocarpine hydrochloride and ½ grain physostigmine benzoate hypodermically three times daily for two days
Aloes	I	1 bolus containing 240 grains aloin, 60 grains calomel, and ½ dram fluid extract of nux vomica; given in 1 quart of water
	II	Cows 207 and 243 each received 1 ounce aloes in a quart of water in the evening, while 262 was given 6 drams each evening on two consecutive days
Magnesium sulphate, sodium chloride and nux vomica	II	Each cow given twice daily for two days the following in a quart of water—8 ounces magnesium sulphate, 4 ounces sodium chloride, 1½ drams powdered nux vomica

RESULTS

The results from the two series of trials will be considered together though tabulated separately.

TABLE 3

Average daily yields for cow 262 in first series of trials

DRUG	PERIOD	MILK	FAT	FAT
		pounds	per cent	pounds
Alcohol	Check	19.2	3.83	0.74
	Experiment	18.3	3.95	0.73
Pituitrin	Check	20.2	3.67	0.74
	Experiment	18.1	3.59	0.65
Pilocarpine and physostigmine	Check	19.4	3.64	0.71
	Experiment	19.2	3.99	0.77
Aloin, calomel and nux vomica	Check	19.4	4.01	0.78
	Experiment	15.9	4.80	0.76

In the trials of the first series with alcohol and aloin all periods were of four days each while in the other two trials the periods were of two days each.

On the whole the use of alcohol depressed rather than stimulated milk and butterfat production. The cow used in both experiments was remarkably uniform in her response to the drug. In all cases there was a slight decrease in total fat yield; and though there was a slight increase in fat percentage in all but one case, the single decrease that did occur was large enough to bring the average down to normal.

As the castor oil administered did not in any case induce purging or even a noticeable laxativeness it may be presumed that the cows were not overdosed, yet in every case there was a decrease in the percentage of fat in the milk and in some cases this was very marked even though the changes in milk yield were hardly appreciable. The total yield of fat also decreased in each case—on one occasion markedly. On the average there was no change in the milk yield but a decrease of about 10 per cent in the percentage and total yield of fat.

The cow used in both series of trials showed a decrease in milk production on both the occasions on which she was treated with pituitrin, while the other animals showed very slight changes

TABLE 4

Average daily yields for cows 207, 243, and 262 in second series of trials

DRUG	PERIOD	COW									AVERAGE		
		207			243			262					
		Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat
		pounds	*per cent*	*pounds*	*pounds*	*per cent*	*pounds*	*pounds*	*per cent*	*pounds*	*pounds*	*per cent*	*pounds*
Alcohol	Check	18.6	4.71	0.88	16.7	4.30	0.72	15.5	4.56	0.71	16.9	4.53	0.77
	Experiment	17.6	4.26	0.75	16.6	4.49	0.75	14.8	4.71	0.70	16.3	4.47	0.73
Castor oil	Check	18.3	4.57	0.84	17.8	3.95	0.70	16.4	4.10	0.67	17.5	4.21	0.74
	Experiment	17.7	3.76	0.67	18.2	3.65	0.67	16.5	3.97	0.66	17.5	3 79	0.66
Pituitrin	Check	16.7	4.98	0.83	17.6	4.55	0.80	16.7	4.44	0.74	17.0	4.65	0.79
	Experiment	17.1	3.63	0.62	17.9	3.89	0.70	15.5	3.74	0.58	16.8	3.76	0.63
Pilocarpine and physostigmine	Check	18.7	4.63	0.86	18.6	3.78	0.70	16.3	4.06	0.66	17.8	4.16	0.74
	Experiment	17.4	4.51	0.79	19.0	4.00	0.76	16.3	4.26	0.70	17.6	4.25	0.75
Aloes	Check	18.5	4.46	0.83	15.7	4.11	0.65	14.8	4.36	0.65	16.4	4.32	0.71
	Experiment	18.4	4.77	0.88	15.5	4.13	0.64	14.7	4.54	0.67	16.2	4.49	0.73
Magnesium sulphate sodium chloride and nux vomica	Check	18.8	4.79	0.90	18.0	4.15	0.75	16.0	4.31	0.69	17.6	4.42	0.78
	Experiment	18.4	4.58	0.84	18.0	4.33	0.78	14.6	4.50	0.66	17.0	4.47	0.76

In the trials of the second series all experimental periods were of two days duration, the check periods for alcohol, castor oil and aloes were of four days each, and all other check periods were of five days each.

in milk yield. In every case there was a marked decrease in total yield of fat and throughout the second series of trials the administering of pituitrin resulted in a marked decrease of the percentage of fat in the milk. The average for the second series showed no appreciable change in milk yield but a decrease of about 20 per cent in percentage and yield of fat.

In the first series there was an appreciable increase in fat percentage and yield of fat when pilocarpine and physostigmine were administered and the cow used in this trial behaved very similarly in the second trial. One of the other cows in the second

TABLE 5

Percentage changes in production for first series of trials

DRUG	PER CENT CHANGE	MILK	FAT	FAT
		pounds	per cent	pounds
Alcohol	Increase		3	
	Decrease	5		1
Pituitrin	Increase			
	Decrease	10	2	12
Pilocarpine and physostigmine	Increase		10	9
	Decrease	1		
Aloin, calomel and nux vomica	Increase		20	
	Decrease	18		3

trial showed an increase throughout very similar to that shown by the cow used in both trials while the remaining animals showed a decrease in milk-yield and percentage and yield of fat. On the average the second series showed no appreciable changes.

The administration of aloes in no case produced purging. In the first series the aloes ball (containing aloin, calomel and nux vomica) induced a phenomenal decrease in milk production with a correspondingly high percentage of fat and on the whole the yield of fat was slightly reduced. In the second series there were no marked changes when the average yields were considered and even the individual variations were comparatively slight.

TABLE 6

Percentage changes in production for second series of trials

DRUG	PER CENT CHANGE	COW									AVERAGE		
		207			243			262					
		Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat
		pounds	*per cent*	*pounds*	*pounds*	*per cent*	*pounds*	*pounds*	*per cent*	*pounds*	*pounds*	*per cent*	*pounds*
Alcohol	Increase					4	4		3				
	Decrease	5	10	15	1			5		1	4	1	5
Castor oil	Increase				2			1					
	Decrease	3	18	20		8	4		3	1		10	11
Pituitrin	Increase	2			2								
	Decrease		27	25		15	13	7	16	22	1	19	20
Pilocarpine and physostigmine	Increase				2	6	9		5	6		2	1
	Decrease	7	3	8							1		
Aloes	Increase		7	6					4	3		4	3
	Decrease	1			1		2	1			1		
Magnesium sulphate sodium chloride, and nox vumica	Increase					4	4		5			1	
	Decrease	2	4	7				9		4	3		3

The mixture of epsom salts, common salt and nux vomica given was accompanied by only slight changes in milk and butterfat yield.

RÉSUMÉ

1. The action of galactagogues on the production of cows has received little experimental study.

2. The results obtained from the use of galactagogues with dairy cattle and even laboratory animals are very conflicting.

3. The drugs used in the present study could not be relied on to induce an increase in the production of milk or in the yield or percentage of butterfat.

4. The most noted changes were decreases in the yield and percentage of butterfat brought about by pituitrin and castor oil.

5. Wide individual variations in their response to the drugs were shown by the cows.

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IMPORTANCE OF SALT IN RATIONS

JACOB JOFFE

Rutgers College, New Brunswick, New Jersey

Referring to the importance of salt in the ration, our eminent investigator, Professor Henry, in his book, "Feeds and Feeding," states: "Though little is known from investigations in this subject, it is evident from the extreme fondness of dairy cows for salt that this article should be regularly and abundantly supplied them." Stockmen, dairymen, farmers recognize the importance of a salt supply; the addition of salt to the feed is a common practice. However, very few feeders give this problem its due consideration, especially as to the amounts of salt, the modifications under different circumstances, the form of supply, etc.

The idea of this paper is an attempt to review the literature on this subject, to bring forth the modern views; and, if possible, to draw some practical conclusions. At first we shall look into the history of the subject; then dwell on the physiological functions produced by the intake of salt; take a glance into the experimental data available and finally draw conclusions.

It is unquestionable that at the time our domesticated herbivora grazed the virgin lands in Asia and Europe, they were provided by nature with salt either in proper grasses or from salt beds. It is a known fact that wild ruminants and hoofed animals seek out salt rocks and pools, and places where salt effloresces, to lick the salt. Hunters take advantage of this in tracing their booty. Just when the domesticated animals began to receive salt as such can only be conjectured; we shall not be out of the way, if we assume that the introduction of salt to man marks also the time of its introduction to animals. The habitual use of salt by man is intimately connected with the advance from nomadic state to agricultural. The reason for this will be clear after we look into the physiological side of the question of salt consumption. The rational application of common salt to the feed of animals runs parallel to the development of rational

scientific methods of feeding. This will lead us to the time when feeding standards began to appear. According to Henry, the first feeding standard appeared in 1810 when Thaer published his "hay equivalents." The further development of the supply of salt to the ration in its historical perspective cannot be taken up in detail; this paper is not simply a historical review. It will, however, be taken up again, when we come to review the experiments in this line.

Now we will turn our attention to the physiological aspect of salt intake.

Bunge in his work "Physiologic and Pathologic Chemistry" says: "The question as to the need of inorganic salt by adult animals cannot be considered as settled." "Among the mineral substances contained in the fluids of the animal body common salt comes first in order of quantity" (Tigerstedt). None of the inorganic salts found in the body appear as such in our diet. Common salt forms the only exception which is the more remarkable as our diet is by no means deficient in it. Henry states: "A moderate addition of salt to the fodder increases the activity of the secretions of the body juices, their circulation, and consequently increases the protein consumption in the body. Salt has a stimulating influence on the appetite, facilitates the passage of albuminoids from the digestive canal into the blood and, in general, increases the energy of the vital processes. Another effect of salt is to increase the excretion of urine. If, after supplying salt, the animal is prevented from drinking water, the water which would otherwise pass off through the lungs and skin, will be diverted to the kidneys; and if the supply from this source is not sufficient, water will further be drawn from the body tissues." This will produce a disturbance and in feeding salt it should be taken into consideration. "Salt accelerates digestion of paracasein lime by the action of rennet" (Zeitschrift Physiologischer Chemie, 1909, pp. 147–163). "Salt in food facilitates the cleavage of amino acids from peptones" (Chemische Zentralblat, 1909). "Surely in most cases, especially in stable feeding, salt is a very desirable condiment. It is necessary in the formation of digestive juices, it supports the digestion of albumin. It

also keeps in solution the albuminoids in the blood circulation. It is well known that the blood serum of mammals contain about 0.5 per cent of NaCl. We find in the stomach and in some parts of the intestines certain amounts of HCl which may be formed from NaCl" (Flugschriften der Deutschen Landwirtschafts Gesellschaft, Heft 10, 1911).

Common salt under certain conditiohs exercises poisonous effects. According to Loeb, a pure NaCl solution is poisonous to animals, the poisonous effect being due to the Na ions. The only reason why the effects are not prominent is due to the fact that there are metal proteids of Ca, K, Mg, and Na in the body and the excess of the Ca and K ions annihilate the poisonous effects of the Na ions. In his paper on ion-proteid compounds, Dr. Loeb cites an interesting series of experiments proving the poisonous effects of a pure solution of NaCl and showing that the more concentrated the solution, the more poisonous it is. This naturally has a great bearing upon the amounts of salt fed to animals. If an excess of NaCl is fed, the Na ions take the place of the other metal ions in the ion-proteids of the tissue, and if it is true that life phenomena depend upon the presence of a number of various metal proteids (Na, Ca, K, Mg) in definite proportions, the equilibrium is disturbed. In testing the duration of life of young fundulus in NaCl solution, Loeb records the fact that in a pure NaCl solution the fundulus died after twelve hours. Diluting the solution, he increased the life duration, and in a 100 per cent distilled water, the fundulus lived the longest. This may lead some to think that NaCl is not so important a factor in the life process; moreover the absence of NaCl prolonged the life of the fundulus. In reviewing the literature on the importance of salt in the ration, the writer met a statement of a Dutch veterinarian by the name WestBroek; he says: "The common belief in the necessity of salt in the diet for domestic animals is not well founded." He argues that the addition of salt to the ration causes more or less serious disturbances in the normal osmotic process, at times greatly changing the tissue and fluids of the animal body. Common salt gradually replaces the salts which should be present in animal tissue and causes patho-

logic conditions. This, however, does not warrant the exclusion of salt from the ration since there is a possibility that the normal supply of NaCl in the feed and drink may not be sufficient for the continued balance of the ion-proteids. Bunge, in the above mentioned work, brings out rather interesting data. He says:

> The desire for salt is more pronounced in the herbivora and *never* in the carnivora. Herbivora need more salt, for vegetable food contain more K and the latter eliminates Cl and Na through the kidneys.
>
> Country people eat three times as much salt as city people. The Mosaic law commands the Jews to present their vegetable offering accompanied by salt. The hunting tribes of Siberia and northern Russia use no salt. The Kalmyks and Kirgisi of the Steppe near the Caspian Sea who take milk and meat only in their diet use no salt.

In the light of these facts, will become reasonable the statement made in the historical review of the subject: that the habitual use of salt came with the advance from nomadic state to agricultural. In the nomadic state we used mostly meat and were similar to carnivorous animals, that never use any salt. As man settled and began to till the soil he also introduced vegetables in the diet. This change created a condition whereby the amount of NaCl taken in was not enough for the normal metabolism in the body, for vegetables contain considerably less NaCl and more K than meat and, as mentioned above, a high K content causes Cl and Na to be eliminated through the kidneys. From what has been said we may feel justified in concluding that NaCl in most cases is essential for normal body functions. An excess of salt is poisonous; whether an omission of salt will produce pathologic effects depends on conditions. If we are able to feed foodstuffs high in NaCl content and low in K, the omission of salt will have no effect. But such conditions are rare. It is only possible on land near sea where we find a number of grasses that have the power to inhibit more NaCl than under far inland conditions. It may also be possible on soils containing a fair amount of NaCl.

Thus we see that in order to avoid pathologic conditions we have to feed a rational amount of salt. The necessary amount can be

determined through experiments. But before the experimental work is taken up it will be well to look into another phase of the subject. We will analyze the proportions of Na and K in different feedstuffs from data available on hand, and endeavor to find a possible clue to predetermine the variable modifications of salt supply in accordance with the different feedstuffs.

The following tables are taken from Bunge's "Physiologic and Pathologic Chemistry."

Table I shows that hay (especially that low in K_2O) contains both a high Na_2O content and a low K_2O content, a condition

TABLE 1

In 1000 parts of dried substances the proportions are:

Arranged according to increasing amounts of K	K_2O	Na_2O
Rice	1	0.03
Bullock's blood	2	19.0
Oats, wheat, rye, barley	5–6	0.1–0.4
Dog's milk	5–6	2–3
Human milk	5–6	1–2
Apples	11	0.1
Peas	12	0.2
Milk of herbivora	9–17	1–10
Hay	6–18	0.3–1.5
Beans	21	0.1
Strawberries	22	1.2
Clover	23	0.1
Potatoes	20–28	0.3–0.6

Arranged according to increasing amounts of Na.	Na_2O
Rice	0.03
Apples	0.07
Beans	0.13
Clover	0.17
Oats, wheat, rye, barley	0.1–0.4
Potatoes	0.3
Hay	0.3–1.5
Human milk	1–2
Dog's milk	2–3
Milk of herbivora	1–10
Bullock's blood	19

whereby the salt requirements are of little importance. On the other hand, if we examine the concentrates: wheat, rye, oats, and barley, we notice that they are relatively higher in K_2O and lower in Na_2O content than is hay. Here we may find it necessary to supply salt. Common practice tells us that when the cattle are out in the pasture, they consume less salt than when kept in stable and fed concentrates. This bears out our conjecture as to the modifications necessary under different environment. In the case of clover, we can see that a still higher per cent of salt supply would be necessary. Table 2 affords a direct comparison, giving the ratio of Na_2O to K_2O, Na_2O being one.

It will be well to notice that milk of herbivora is in the center of table 1 and first in table 2. Graphically, it represents that milk is the ideal food in respect of salt requirements, and we know that this is true. It seems plausible to the writer that standards of salt requirements may be fixed, taking the milk of the herbivora as the ideal one. It would be highly interesting to conduct a series of experiments in this line. So far as the writer could find out, no work has been attempted for this purpose.

Now we will turn our attention to the experimental work in connection with salt requirements in the dairy ration. Only few experiment stations have attempted to do work of any impor-

TABLE 2

For one equivalent of Na_2O the equivalents of K_2O are:

Milk of herbivora	0.8–0.6
Wheat	12–23
Barley	14–21
Oats	15–21
Rice	24
Rye	9–57
Hay	3–57
Potatoes	31–42
Peas	44–50
Clover	90
Apples	100
Beans	110

tance. Wisconsin, Mississippi, Kansas, and Ontario are in order of importance. This paper will treat the work of the Wisconsin Station, for it summarizes the work of the others. The name of Dr. Babcock, who was connected with the work at Wisconsin, makes it more valuable.

Dr. Babcock reviews the work of other experimenters. Boussingault in 1847 and later in 1854 conducted experiments to ascertain the effects of salt on the milk flow. In both cases he fed hay, all the cows wanted, for periods from fourteen to twenty-one days without salt, then gave salt at the rate of two ounces per day for a period of sixteen to twenty-seven days. No increase in the milk flow was noticed. Later experiments by Bahr and Wolf showed that although the addition of salt caused an increase

in the weight of the animal, yet it had no effect on the milk yield. It seems to the writer that these experiments cannot prove that a deficiency in salt will not decrease the milk flow. The purpose of the experiments should be to ascertain whether an addition of salt will increase the yield in cases where such is deficient. Boussingault's experiments were conducted with hay feed, and the latter is usually high in Na_2O and low in K_2O: these are the conditions where no salt is of great importance. In an experiment conducted by Richter in 1855 where the kind of feed is not stated we do find an increase in milk flow: one pound per day. In all probabilities the feed was low in Na_2O, high in K_2O. Professor Robertson from the Ontario Experiment Station had four groups of cows: two groups were fed without salt, the other two had all the salt they wanted. In two days the two non-salt groups fell off 17.5 per cent in their milk flow. He also noticed that, "the milk of the unsalted cows turned sour in twenty-four hours less time than the milk from the salted cows." Experiments conducted by Lane in 1861 showed, that when cows were given 2.5 ounces of salt per day the per cent of solids in the milk was 13 per cent, while when he doubled the quantity of salt, the total solids amounted to only 8 per cent. Here we have a case of the harmful influence of an excess of salt. The Mississippi Station Report of 1888 gives data of an experiment whereby three "salted" cows showed a gain of 110 pounds of milk in two weeks. The amount of salt given was four ounces per day. It is very likely that the feed was very low in Na_2O and high in K_2O. Dr. Babcock conducted two series of experiments: one in 1899, the other ten years later. Both series dwell mainly on the influence of salt on the milk flow. In the first test in 1899 there were two lots of cows, three in each. One lot received salt, the other did not. The experiment covers a period of three months. The salted cows were given 2 ounces a day. After ten days they refused to eat up this amount, and 1 ounce was given; this was eaten up. The production figures apparently do not show any advantage for salt. It is the writer's opinion that no increase should have been looked for. The cows refused to eat up 2 ounces of salt and this phenomenon occurred after the animals had been

turned out on pasture, the latter consisting mainly of blue grass. It would be interesting to find out the Na_2O and K_2O ratio in blue grass. The writer ventures to assume that the blue grass was supplying most of the salt necessary. Dr. Babcock seems to doubt his own conclusions by advising the use of salt, although he tries to show that the addition of salt even decreased the yield.

In test II, conducted ten years later, e.g., in 1899, the same purpose was followed as in 1888. The period of time was prolonged one year; salt was fed to the "salt cows" on alternate months. The reason for the latter was not given. There were two lots, eight cows in each one. Lot I received no salt, lot II received salt on alternate months. In the latter experiment the length of time with no salt in the ration varied. It ranged from two and one-half to fifteen months. After being deprived of salt for three weeks, all of the cows became exceedingly hungry for it. They would lick the mangers, walls of the stable, and hands and clothing of the attendants. Some would eat horse manure; in one instance a cow chewed up a piece of old clothing saturated with perspiration. All of the cows were eager to lick the dust of the car tracks, which had been salted during the winter to remove ice. Shortly after being turned out to pasture, several of the cows began to scour badly, their excrements having the appearance of dried mud. This condition was found to be caused by the consuming of large quantities of salt from a spot in the field where a considerable amount of salt had been deposited a year before. In the case of lot I two cows had to be supplied with salt before their time was up. In both cases the cows became sick and after a supply of salt they recovered. Both cases appeared after calving. Alma, a cow from lot II, which had received no salt for two and one-half months became sick with colic, vomiting large quantities of undigested food. She was given eight ounces of salt in water as a drench; this was followed by one ounce daily and she recovered. Goodrich, another cow of lot II, was taken sick in the same manner as Alma. After she was fed salt for a few days she recovered. As the period of time in the experiment advanced, more and more cows of lot II took sick; in every case upon the addition of salt they recovered.

Sickness caused loss in flesh and diminished the milk flow. There was only one cow that completed the whole year without salt. Her period of no salt was, therefore, continued for three months more. She continued in apparently good condition until just before calving and after calving she died.

Dr. Babcock concludes that it is possible to hold a cow without salt for two months under conditions existing in Wisconsin. After that time the vitality of the animal is impaired. If calving occurs after the cow has been deprived from salt for a considerable period of time, there is danger of a sudden collapse. This brings out very strikingly the importance of salt for pregnant animals.

Comparing the quantity and quality of milk in the two lots, Dr. Babcock points out that lot I gave a total of 47,531 pounds of milk, lot II, 45,659 pounds. Commenting on these figures, Dr. Babcock states: "The data presented give no evidence that the yield of milk is influenced in any way by giving salt to the cows." The writer feels puzzled by this statement. It is true we cannot dispute figures, but even then a little analysis of the experiment and figures will be taken up and commented upon. First of all we notice that every cow of lot II got sick after a certain period. Sickness is usually the culmination point of gradual accumulation of disturbances. Thus the cows were not normal at all times of the experiment. Still they produced nearly as much as the cows of lot I. The individual characteristics of the cows kept up their record and if salt would have been supplied, lot II would have exceeded lot I. In the second place we do have an increase of 2000 pounds of milk, or 250 pounds per cow. Dr. Babcock minimizes this increase by stating, that it may be due to individual peculiarities of the cows. The same may be argued in favor of lot II, e.g., the fine showing lot II made without salt is due to individual peculiarities. It seems to the writer that experimenting with one lot of cows only, giving salt at certain periods and then withholding it for a time, would be of greater value.

Dr. Babcock has yet another test. This consisted of a lot of cows which were deprived of salt. No comparisons were made with other cows. The results were the same as in previous experiments: the cows endured the lack of salt for a certain time and

broke down. This was accompanied by a loss in weight and drop in production. It is interesting to note that the Cl content in the milk increased. The reason for this is not given. It does, however, explain the phenomenon mentioned earlier in this paper that milk from unsalted cows sours more quickly. Chlorine is an acid forming element.

Summing up the experiments, Dr. Babcock advises the use of at least one ounce of salt per 1000 pounds weight for a dairy cow, with 0.6 ounces for every 20 pounds of milk.

The Kansas Agricultural College reports "that cattle brought to the college are very greedy for salt. If allowed to satisfy their desire, they will consume so much that it greatly deranges the process of digestion. After the cattle become accustomed to the salt, it can be kept before them at all times with no bad results." In the Kansas herd salt is supplied in boxes under the sheds and replenished as often as necessary. The salt is weighed out in 2-pound bags for ten or twenty cows, and this amount is placed at a time so as to keep the supply fresh. Only barrel salt is used, rock salt being coarse and having an irritating effect.

The Kansas Station reports the amounts of salt used by calves. It also gives the kinds of feed.

NO. OF LOT	NO. OF HEADS IN LOT	KIND OF FEED	AMOUNT OF SALT USED UP
			pounds
1	20	Shelled corn and alfalfa hay	36
2	20	Kaffir corn and alfalfa hay	42
3	20	Shelled corn, ½; soy beans, ½; prairie hay, ½	50
4	20	Kaffir corn, ½; soy beans, ½; prairie hay, ½	60
5	10	Shelled corn and alfalfa	24
6	10	Shelled corn and alalfa	39 { 14 pounds ate at will; 25 pounds fed in feed
7	10	Shelled corn and alfalfa and a condimental feed	12
8	10	Shelled corn	34
9	10	Shelled corn	16

There were nine lots and the following table will show the amount of salt used with the different feed.

It will be noticed that soy beans and Kaffir corn increase the salt requirements. In case of lot 3 and 4 the increase of 10 pounds is due to the Kaffir corn only. Lot 8 was raised on skim milk, lot 9 on whole milk. It shows that the skim milk ration requires more salt. As a whole this experiment suggests what has already been mentioned, that the salt requirements differ with the kind of feed.

In the introduction the writer says: The idea of this paper is an attempt to review the literature on the subject, to bring forth the modern views, and, if possible, to draw some practical conclusions." Whether the writer succeeded in the first two aims, he refrains from stating; the generous criticism of his readers and hearers is welcome. As to the last aim the following may be stated: salt is one of the important ingredients in the ration. A lack of salt will produce pathologic conditions, bringing forth a loss of flesh, vitality, and consequently a decrease in production. Cows should have free access to salt. Cows should get between 2 and 2.5 ounces of salt, the amounts to vary with the feed. The latter is applicable to stable feeding where the salt is mixed with the feed. As stated in the course of the discussion standards would be welcome.

It may be said in conclusion that more light on this subject is still waited for.

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A COMPARISON OF BACTERIA COUNTS IN WHOLE AND SKIM MILK, SEPARATOR AND CENTRIFUGE CREAM

R. W. LAMSON

Bureau of Chemistry, United States Department of Agriculture, Washington, D. C.

There are two classes of unmanufactured dairy products most commonly found upon the market, namely, whole milk and cream. The former at least is subject to some sort of sanitary supervision by nearly every commission having anything to do with food control work. The basis for their enforcement of such a pure food regulation is usually a standard or tolerance of bacteria per cubic centimeter. In many cases no standard is prescribed for cream, or, if so, it is usually much more liberal than the milk standard. In fact, it is customary to allow from five to twenty times as many bacteria in the cream as in the whole milk.

An extensive study of this subject was made several years ago by the New York milk commission (1.) Their report contains the following: "In 20 per cent cream, the count shall not be more than five times the limit for the same grade of milk." The source of the number "5" is not given, but a study of the literature on this subject reveals the fact that most workers have reported from five to twenty, or more, times the bacteria in cream that there was in the milk from which it was obtained. The reason for this will be explained later.

The tendency to judge the sanitary character of milk products on a bacteria count is sure to increase, hence it is very important that a fair standard of tolerance be established. Many companies are now buying from their patrons on a combined basis of butter fat, and bacterial content, and they are at a loss to know whether or not to make the same limit of bacteria for both milk and cream.

From an extensive observation of the conditions in Canada and Eastern United States, I am convinced that nearly all the

cream on the market is separated from milk by one of the several forms of cream separators. The gravity separation is a method that has generally been discarded, this being equally true of dairies with only a few cows, hence this paper deals with the method in most common use. This fact has an important bearing upon an interpretation of the limited amount of literature on this subject. Dr. Anderson (2) reports the result of a large number of analyses, most of these being made upon cream separated from milk by the gravity method. He also reports results of analysis of cream raised by centrifugal force. In brief, his conclusions are: "Top milk (by gravity method) often contains 10 to 500 times as many bacteria as were in the mixed milk. Centrifugally raised cream [*Note:* Not commercial separation] contains more bacteria per cubic centimeter than the gravity cream from the same milk." The centrifuge experiment was conducted in a flask or bottle and should not be taken to mean a commercial separator where the separation also depends upon centrifugal force. Scheurlen (3) apparently conducted his experiment by the use of a centrifuge, and he found a marked decrease in bacteria in bottom milk and a marked increase in the sediment and cream. Russell (4) states in his book that separator cream should have no more bacteria per cc. than gravity cream if the separation is done properly. Several other workers have reported somewhat similar findings, and it appears that the results obtained from gravity cream and that separated in a container in centrifuge have been considered to be similar to what might be expected in a commercial separator. Heinemann (5) states that separator cream contains a smaller number of bacteria per cubic centimeter than the whole milk from which it was obtained. In a later work (6) he further states "that the number of bacteria in separator cream decrease proportionately as the fat content increases."

The apparent discrepancy and misinterpretation of results offered the suggestion for the piece of work reported in this paper. The plan of the work was briefly as follows: Total count of bacteria in whole milk, in cream and skim milk separated from this by a commerical cream separator, in cream and skim milk separated

TABLE 1

Bacteria per cubic centimeter in whole milk, cream, and skim milk

SAMPLE		WHOLE MILK	SEPARATOR SKIM MILK	SEPARATOR CREAM	CENTRIFUGE SKIM MILK	CENTRIFUGE CREAM	PER CENT BUTTER FAT IN		CENTRIFUGE	
Laboratory number	Analyst						Separator cream	Centrifuge cream	R. P. M.	Period
										minutes
14703	L	2,700	4,500	26,850	115,000	180,000	25.45		2,000	20
	R	4,300	3 000	2,000	55,000	110 000				
	N	1,600	2,050	1,050	2,000					
14705	L	11,000	9,300	15,000	700	330,000	13.77	64.32	2,100	20
	R	9,500	7,500	13,750	500	170,000				
	N	9,700	8,950	8,650	150					
14707	L	4,700	3,950	2,900	500	52,500	36.89	65.79	2,100	10
	F	2,250	4,100	8,600	6,800	4,180,000				
	N	3,000	3,900	1,850	100					
14708	L	760,000	315,000	1,280,000	147,000	15,750,000	44.05	64.59	2,100	10
	F	7,550,000	2,750,000	15,900,000	1,150,000	93,600,000				
	S	550,000	300,000	535,000	285,000	13,500,000				
14709	L	12,400	9,300	5,700	600	237,500	40.31	68 76	2,200	10
	N	5,500	11,500	4,700	250					
	S	10,000	7,400	5,500	550					
14712	L	5,450	2,000	5,000	550	82,500	45.28	64.56	2,100	10
	N	9,500	4,300	3,300	500	147,500				
	S	12,800	5,350	3,100	350	103,000				
14714	L	13,500	10,700	12,500	6,500	163,000	54.77	65 86	2,100	10
	N	11,000	10,000	5,250	3,500	16,000				
	S	17,300	11,500	13,600	5,900	126,000				
14715	N	27,500,000	21,100,000	58,300,000	17,500,000	484,000,000	48.76	63.69	2,100	10

14717	L	19,150,000	8,950,000	12,900,000			67.18			
	N	8,700,000	4,700,000	2,810,000						
	S	15,500,000	12,850,000	16,950,000						
14722	L	104,175,000	18,100,000	114,000,000			55.91			
	N	111,000,000	52,500,000	80,500,000						
	F	109,975,000	35,000,000	95,500,000						
14723	L	22,850,000	3,265,000	23,900,000	1,510,000	122,500,000	32.15	64.49	2,100	10
	S	18,000,000	6,800,000	23,700,000	1,950,000					
	N	17,400,000	5,350,000	37,300,000	2,545,000					
14724	L	4,300,000	1,950,000	4,400,000	925,000	54,000,000	30.67	60.44	2,100	10
	S	5,700,000	2,110,000	4,200,000	730,000	79,000,000				

in a bottle by centrifugal force, and lastly a determination of the butter fat in each cream sample. It was desired to try this on high as well as low count milk, as it was noted that most of previous data were based on relatively low count milk.

In order to eliminate the personal equation as far as possible, at least three analysts examined all but two of the samples in the preliminary studies. Wherever available, the results of the same three analysts are used in the table.

In the first part of this work great care was taken to control the conditions, and this seemed to be justified by the consistent results obtained. The separator parts were thoroughly sterilized before use and put into the machine as aseptically as possible. A large sample, 1 to 2 pints, was collected from the separator spouts in sterile receptacles. For the centrifuge experiment four sterile 250 cc. salt mouth bottles were used. These were covered with sterile parchment paper during the centrifugal process The cream in each of the four bottles was composited into another sterile bottle. In each case I prepared the analyst's portion in the following manner: the milk or cream was vigorously shaken 100 times with sterile glass shot and portions of about 25 cc. were removed in an aseptic manner and placed in sterile containers; each analyst was given an individual subsample.

The following analysts in the Microbiological Laboratory, Bureau of Chemistry took part in this work and their results are indicated by their initial: Dr. L. A. Round, S. K. Farrar, W. R. North, Jr., D. Soletsky and R. W. Lamson.

Mr. J. T. Keister, of the Food Control Laboratory, Bureau of Chemistry, determined the fat content on all the cream samples.

The results reported represent an average of duplicate plates made on standard plain beef extract-peptone agar-agar incubated forty-eight hours at 37.5°C. except those in table 4, where only the Breed microscopic count was used. All methods are those prescribed by the Standard Methods Committee for milk analysis.

An observation of table 1 indicates that the several analysts agree very closely in their findings, and further that the number of bacteria in the original whole milk did not materially influence the proportions found in the cream and skim milk.

The last two columns give the number of revolutions and length of time of centrifuging for the cream and skim milk separated in centrifuge bottles.

There may be some criticism of these results because of the fact that the separator cream is somewhat heavier than that commonly found on the market. This may be partly true, but the tendency is toward the separation and shipping of relatively heavy cream in order to save transportation and handling charges, because the cream producers are usually those located farthest from the markets. This heavy cream is then modified in final plant to the desired butter fat content, hence the higher percentage cream represents more truly the condition of production and handling.

TABLE 2

Percentage count of each class of the product considering whole milk as 100 per cent

NUMBER	SEPARATOR SKIM	SEPARATOR CREAM	CENTRIFUGE SKIM	CENTRIFUGE CREAM	PER CENT BUTTER FAT	
					Separator cream	Centrifuge cream
14703	107	347	1,997	5,052	25.45	
14705	80	117	4	2,336	13.77	64.32
14707	120	137	74	63,738	36.89	65.79
14708	38	200	18	1,386	44.05	64.59
14709	101	57	5	2,554	40.31	68.76
14712	42	41	5	1,200	45.28	64.56
14714	77	75	38	732	54.77	65.86
14715	77	211	74	1,760	48.76	63.69
14717	61	75			67.18	
14722	33	90			55.91	
14723	27	146	10	629	32.15	64.49
14724	40	86	17	1,330	30.67	60.44

The above percentages represent all counts under each number. The counts of the different analysts were added together and the average of the total count on each sample of whole milk represented 100 per cent. Hence 200 per cent indicates that such a count was twice that obtained on the whole milk. And in like manner 50 per cent indicates that the count was but one-half that found in whole milk. It will be noted that three-fourths of the average percentages for the separator cream are lower or but

very slightly higher than the count obtained on whole milk. It is also interesting to note that the count on centrifuged cream usually averages between six and twenty-five times the total count on whole milk in the same sample. It also appears that the skim milk usually contains considerably less bacteria than the milk from which separated.

TABLE 3

Comparison of per cent of butter fat with per cent of bacteria count in separator cream

NUMBER	BUTTER FAT	BACTERIA
	per cent	*per cent*
14705	13.77	117
14703	25.45	347
14724	30.67	86
14723	32.15	146
14707	36.89	137
14709	40.31	57
14708	44.05	200
14712	45.28	41
14715	48.76	211
14714	54.77	75
14722	55.91	90
14717	67.18	75

In the above table the results are arranged in order of increasing per cent of butter fat. It may be noted that there is a slight indication that an increase in butter fat results in a decrease in percentage count of bacteria. This is doubly interesting when considered in connection with the counts obtained on the centrifuge cream in which the percentage of butter fat was always 60 per cent or more, and where never less than six times the bacteria of whole milk were found.

In order that these results might more nearly represent trade conditions, the writer, while engaged in milk work in northern New England during the summer of 1917, secured the results presented in table 4. These samples were collected whenever a creamery was visited in which a commercial separator was in operation. No attempt was made to control the conditions of handling, but samples were collected in an aseptic manner from

the whole milk running into the top of the separator, and immediately after similar samples were collected from the cream and skim milk spouts. In this way representative commercial conditions were obtained. Little is known about the cleaning these separators received before being used. The method of analysis for all these samples was the Breed microscopic count, counting groups only. Previous extended studies have indicated that this method, as used by the writer, will approximate the count on plain agar, when applied to the raw product.

TABLE 4

Bacteria counts of whole milk, separator cream and skim milk; Breed microscopic count bacteria per cubic centimeter

PLANT	WHOLE MILK	BACTERIA CREAM	SKIM MILK
A	4,000,000	7,000,000	7,000,000
B	4,700,000	5,900,000	1,600,000
C	15,000,000	27,000,000	16,000,000
D	1,200,000	600,000	400,000
D	7,500,000	9,300,000	23,300,000
E	7,800,000	7,300,000	2,300,000
F	5,000,000	14,000,000	4,600,000
Total	55,000,000	71,000,000	59,000,000
Average	8,000,000	10,000,000	8,000,000

It is to be regretted that more analyses are not available for the above table, but those presented are in agreement with the results obtained in the preliminary studies, namely, that cream should not be judged by a more lenient standard than milk. In only one case was the count on the cream twice that on the whole milk, and in this case the separator was not working properly, having stopped two or three times previous to taking these samples. An average of all the counts shows the cream to have but 25 per cent more bacteria than the milk from which separated, and this figure is well within the limit of error.

The writer's experiences during the past three years have shown that it is easily possible for large lots of bulk cream to be marketed with counts of much less than 1,000,000 bacteria per cubic centi-

very slightly higher than the count obtained on whole milk. It is also interesting to note that the count on centrifuged cream usually averages between six and twenty-five times the total count on whole milk in the same sample. It also appears that the skim milk usually contains considerably less bacteria than the milk from which separated.

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D	1,200,000	600,000	400,000
D	7,500,000	9,300,000	23,300,000
E	7,800,000	7,300,000	2,300,000
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The writer's experiences during the past three years have shown that it is easily possible for large lots of bulk cream to be marketed with counts of much less than 1,000,000 bacteria per cubic centi-

meter. In most cases this represented the mixed product from a large number of dairies, none of which are above the average in sanitary efficiency. Thus it is seen that we are dealing with a commerical possibility; and in fairness to the producer of whole milk it is suggested that cream standards be not made more lenient than those for whole milk, unless those making such standards have conclusive analytical data that such is a fair arrangement. The writer is satisfied that a uniform standard is commercially desirable.

SUMMARY

These results indicate quite strongly that there are usually less or only slightly more bacteria in separator cream than in the whole milk from which separated. Also that centrifugally raised cream in closed container showed from six to twenty-five times as many bacteria as were found in the original milk.

The skim milk usually contained fewer bacteria than the whole milk.

There does not appear to be any sharp relation between increase in butter fat, at least above 25 per cent, and the percentage of bacteria found in the cream.

These results for separator cream are in quite close agreement with the findings of other investigators who actually worked on separator cream. The results obtained on centrifuge cream are also very similar to those reported by other writers on this class of product.

The comparison between the two types of cream from the same whole milk indicates that it is erroneous to interpret the results on centrifuge cream as comparable to what would be found in commercial separator cream.

From this and other investigations on commercial separated cream it would appear desirable to have a common bacteriological standard for market whole milk and cream.

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PRODUCTION OF ACID PHOSPHATE FROM CREAMERY WASTE SULPHURIC ACID

R. H. CARR

Purdue University, LaFayette, Indiana

During the existence of the unsettled state of affairs caused by the present war, anything which tends to conserve or increase our munitions and our food supply commands the attention of all thoughtful people. Since the outbreak of the war, the demand for sulphuric acid, which is very great even in time of peace, has been greatly increased. This increase has caused an increase in the price of acid phosphate as well as a scarcity of it and this will in turn cause a decrease in crop yield because it will interfere with its continued use as a fertilizer. The need for both the acid and the phosphate led the writer to make in Indiana some investigations of the waste acid connected with the dairy industry with a view to the possible utilization of this waste to increase our production of acid phosphate and to cause a consequent saving of our acid for explosive manufacture.

AMOUNT OF SULPHURIC ACID USED

Requests were sent to ten of the large dairy plants concerning the amount of sulphuric acid used in their fat testing work and returns show that an average of 4000 pounds of acid were used by each company per year. One company reported using 40,000 pounds during the past year. Although the survey was far from complete, enough data were obtained to show the possibilities of further use of the sulphuric acid in making enough acid phosphate to materially increase crop production if it could be utilized. The amount of acid used in the fat test varies considerably with the temperature and richness of the cream and with the different testers as the amount of acid to be added is determined, by the degree of blackening or charring produced where the acid is added to the cream to be tested (from 8 cc. to 12 cc. of 1.83 acid is used).

But on the whole the analysis of mixture of cream and acid after the tests were completed and fat removed had approximately the following composition.

Percentage composition of waste acid

	per cent by weight
1. (H_2SO_4) sulphuric acid sp. gr. 1.200	27.32
2. Nitrogen (Ammo acids, peptones, etc.)	0.054
3. Ash (potassium and calcium, etc.)	0.11
4. Volatile organic matter	0.56
5. Sugar (lactose)	0.525

METHOD OF MANUFACTURE

It has been found desirable in making acid phosphate from rock phosphate to use 60 per cent acid instead of the concentrated because water is necessary in order to form a hydrated calcium sulphate, also a hydrated mono-calcium phosphate. Since a 60 per cent acid is needed instead of 27.32 per cent as shown in analysis, it would seem a simple matter to concentrate the waste by passing the waste steam of the creamery through a lead coil contained in an acid proof jar with an outlet at the bottom to draw off the concentrated acid into a carboy and also one near the top to draw off the fat. This waste fat somewhat purified by live steam treatment has a market value of about fifteen cents per pound and in the case of the one company mentioned the fat from this source amounts to nearly 35 pounds a day. This fat should not be permitted to go to waste. A lead coil and jar suitable for many plants should not cost more than $15. Other devices for concentrating the acids may be employed as conditions seem to justify. The concentrated acid could be mixed with the ground rock phosphate in a cement mixing box (wooden) and after the first reaction is over (few hours) could be shoveled into bins to "ripen," thus avoiding any further expense. Usually the highest grade rock obtainable is used (78 per cent to 80 per cent calcium phosphate) and it is ground to pass an 80 mesh sieve. It is usually mixed in the proportion of 1 pound of rock to 1 pound of 60 per cent acid,

giving a yield of abou 1.9 pound of acid phosphate, the loss (about 10 per cent) being partly due to evaporation of water caused by the heat of reaction and the subsequent drying.

CHEMICAL CHANGES INVOLVED

The amount of acid used in comparison with the rock is a matter of much importance and to get the *highest efficiency* it should be controlled by a chemist. If too much acid is used there is a tendency to form an excess of free phosphoric acid. This attracts moisture from the air and makes the fertilizer lumpy. If too little acid is added there is a tendency for the acid phosphate to revert to the di-calcium phosphate which is less water soluble.

Reaction:

(1) $Ca_3PO_8 + 2H_2SO_4 + 6H_2O = \overbrace{\underbrace{(CaH_4P_2O_8 + 2H_2O)}_{\text{desirable}}}^{} + (CaSO_4 \cdot 2H_2O)$

(2) $Ca_3P_2O_8 + 3H_2SO_4 + 6H_2O = \overbrace{\underbrace{2H_3PO_4}_{\text{excess undesirable}}}^{} + 3(CaSO_4 \cdot 24_2O)$

(3) $Ca_3P_2O_8 + H_2SO_4 + 6H_2O + \overbrace{\underbrace{(Ca_3H_2P_2O_8 \cdot 4H_2O)}_{\text{undesirable}}}^{} + (CaSO_4 \cdot 2H_2O)$

The writer finds that the sugar is mostly carbonized on concentrating the acid to 60 per cent and if diluted some of the carbon will settle out. However, the 60 per cent acid retains most of the carbon in suspension or colloidal solution which gives it a black color. The carbon seems to be of some advantage to the acid phosphate as it tends to keep the mass granular and porous. The other impurities in the acid are compounds of nitrogen, calcium, potassium, and phosphorus. They are in water soluble form and are an advantage to the fertilizer. The percentage of these constituents in 60 per cent acid are more than double the amounts given in analysis due to greater concentration. The acid phosphate manufactured from the waste acid had approximately the following composition:

Percentage composition of fertilizer

Potassium sulphate	0.357
Acid phosphate	14.000
Nitrogen as (NH_3) (present as amino acids)	0.232

Figuring these in pounds per ton we obtain 7.14 pounds of potassium sulphate, 122 pounds of acid phosphate, 4.64 pounds of nitrogen expressed as ammonia. Thus it will be noted that the impurities in the acid are of value to it in the manufacture of this fertilizer.

PHOSPHORUS DEFICIENCIES IN SOILS

Phosphorus is the plant food element most deficient in the majority of our soils, it being one of the important ones removed from the land by the sale of many farm products, grains, milk, livestock, etc. and thus it is lost to further crop production. It requires about 23 pounds of phosphorus to grow 100 bushels of corn or 1 pound of phosphorus for 4.35 bushels. At this rate the acid now wasted by the 10 companies referred to would be sufficient, if it could be utilized, to furnish phosphorus to raise 32,276 bushels of corn.

CONCLUSION

In conclusion it may seem that the amount of acid phosphate that might be produced at any one place is not large compared to the ou put o a factory producing 350,000 tons per year, yet when one considers the amount of fertilizer possible to make over the whole United States from this waste acid with no appreciable additional expense, it would certainly seem to be worth while. Again the fact that acid phosphate made in this way carries enough nitrogen and potassium to make it worth several dollars more per ton than the usual product upon the market is additional evidence in its favor. Hence, it would seem that both the acid and the fat are too valuable products to be poured down the sewer while acid phosphate is becoming scarcer and higher in price.

A STUDY OF THE EFFECT OF COTTON STOPPERS USED IN DILUTION BLANKS ON THE NUMERICAL BACTERIAL COUNT, AND OF OTHER PRACTICES IN THE TECHNIQUE OF BACTERIOLOGICAL LABORATORIES

ROY S. DEARSTYNE

City Health Department, Baltimore, Maryland

In bacteriological laboratories where large quantities of dilution blanks are in daily use, the question of the actual effect of the use of cotton stoppers in such blanks on the numerical bacterial count has become a matter of such moment that it was decided to investigate this matter in order to learn if the detrimental effect of these stoppers was such as to cause the discarding of this style of blank, and the adopting of the glass stoppered bottles—a step which would nece sitate a large initial expense and a continued additional expenditure for handling and upkeep.

Our winter schedule of milk and water analysis necessitates the use of 600 six-ounce water blanks and 1100 one-ounce water blanks weekly, while during the summer months, approximately 1100 large and 600 small blanks are used. From the number used, the large amount of handling this glassware receives can be seen, and besides the expense, double sterilizing, cleaning room, and cabinet space would be needed, because in order to handle the glass stoppered blank successfully, each stopper should be chained or wired to its respective blank. Hence, we believe that the investigation of this phase of our work was necessary, and think that the results obtained warranted our work in this line.

In this experiment, 100 samples were used, and the following technique was employed—a sterile 99 cc. water blank was inoculated with 1 cc. of milk, and was rotated until the fluid seemed fairly uniform, care being taken not to allow this fluid to come in contact with the stopper. From this blank, 1 cc. was inoculated into a sterile petri dish marked "1A." The blank was then shaken twenty-five times as required by Standard Methods of

Milk Analysis, and 1 cc. was placed in a sterile petri dish marked "1B." The stopper of this blank was then taken, and with sterile paper, the fluid retained by the stopper was forced into a small sterile blank, and 1 cc. of this fluid was inoculated into a sterile pertri dish marked "1c." These three dishes were inoculated with approximately 10 cc. of nutrient agar, and incubated for forty-eight hours at 37.5° C., and it is on the results of 100 such series that our conclusions are founded.

Calling the inoculations made from the rotated sample "A," the same sample shaken "B," and the exudate from the stopper of this shaken blank "C" we have the following results:

Aggregate total "A"—100 samples actual count	9876
Aggregate total "B"—100 samples actual count	9069
Aggregate total "C"—100 samples actual count	7969
Excess count of "A" over "B"—aggregate	807
Excess count of "A" over "C"—aggregate	1907
Excess count of "B" over "C"—aggregate	1100

In the series of 100.

"A's" count was highest 56 times
"A's" count was 2nd highest 35 times
"A's" count was 3rd highest 9 times
"B's" count was highest 34 times
"B's" count was 2nd highest 48 times
"B's" count was 3rd highest 18 times
"C's" count was highest 10 times
"C's" count was 2nd highest 17 times
"C's" count was 3rd highest 73 times
The average count of "A" was 98.8
The average count of "B" was 90.7
The average count of "C" was 79.7

These averages would tend to show that in every 100 organsims per cubic centimeter there is lost by shaking the blank approximately 8 organisms which adhere to the stopper or 8 per cent. If the stopper drains dry, or is compressed to loose all its moisture, there still is retained around 20 organisms per 100 or the amount shaken, and the results show that the exudate given off by the stopper contains less bacteria than the fluid shaken against it.

To prove that the strands of cotton retain the organisms, in 25 cases, these strands from the compressed stoppers were picked

under sterile conditions, inoculated into melted agar tubes, and plated out. In each case, after forty-eight hours incubation at 37.5° C., the plates showed innumerable colonies growing along the strands of picked cotton.

Regarding the general impression that cotton stoppers increase the count by lessening the dilution, we would state that we consider this factor almost negligible, inasmuch as we found in trying to run some experiments on the quantity of the dilution retained, that if the blanks stood for two minutes or less, that it was almost impossible to secure a cubic centimeter, and that the inconsistency of the stoppers was such as to preclude accurate work on this phase.

On the basis of the work done, this department has deemed it advisable to eliminate the cotton stoppered type of blank and adopt the glass stopperedtype.

DOES B. SUBTILIS OR OTHER SPORE-BEARING ORGANISMS IN THE CENTER OF COTTON STOPPERS SURVIVE HOT AIR STERILIZATION?

The frequent appearance of B. subtilis on agar plates in our routine work led us to investigate as to whether or not this organism survived our sterilization temperature, 200° C., for one hour. In this investigation strands were picked under sterile conditions from th center of cotton stoppers which had been sterilized, and were immersed in melted agar tubes. These tubes were plated and incubated for forty-eight hours at 37.5° C.

Of the 30 stoppers picked, 24 proved to be sterile; 4 had 1 colony; 1 had 3 colonies, 1 had 4 colonies, and 1 was contaminated. This investigation was not continued further, as the results show that as far as routine work is concerned, this phase of the cotton stopper question was acceptable.

THE AGITATION OF ORIGINAL PACKAGES OF MILK BY HAND IN ORDER TO SECURE AN EVEN BUTTER FAT DISTRIBUTION FOR TAKING A BACTERIAL SAMPLE

Owing to the lack of a satisfactory mechanica agitator for original packages of milk, our technique in preparing these pack-

ages for the taking of a bacterial sample consists of thoroughly shaking these bottles with the cap both up and inverted. In order to ascertain if the butter fat was evenly distributed, and that the sample taken was fair in every way, fifty of these packages were run for butter fat content in the following manner:

The samples were shaken in the customary manner and 17.5 cc. was taken from the zone of our 1 cc. delivery pipette, and another 17.5 cc. taken about a half inch from the bottom of the bottle, and Babcock tests for butter fat were run on these samples. The following results were obtained, calling the top portion zone "1" and the bottom zone "2."

PER CENT DIFFERENCES	TOTAL	ZONE 1—HIGHEST PER CENT BUTTER FAT	ZONE 2—HIGHEST PER CENT BUTTER FAT
0.00	13	—	—
0.05	4	2	2
0.10	8	6	2
0.15	3	1	2
0.20	7	7	—
0.25	1	1	—
0.30	5	3	2
0.35	1	1	3
0.40	4	1	—
0.50	2	2	—
0.60	1	1	—
0.70	1	—	1

These samples represented every type of capping on the market and included samples where there was little or no space between the cap and milk line as well as those with a fairly large space.

We conclude that this manner of agitation gives a representative sample, and is fair to all concerned.

A STUDY OF THE PROPAGATION OF BACTERIA IN GLASS AND IN PAPER CONTAINERS

Testing out the assertion that bacteria would not propagate rapidly in patent paper milk containers as in the commonly used glass bottles, a series of experiments was carried out on this question.

Five duplicate samples were placed in both the glass and paper bottles and these were subject to the following temperatures,—50° F. (2); 35 to 40° F.; 68° F.; and room temperature. Counts were run at as regular intervals as possible for three days, using the technique of the Standard Methods of Milk Analysis.'

The results of these experiments show that there is practically no difference in the propagation in the different containers.

FIELD SURVEYS AND DAIRY MARKETING INVESTIGATIONS[1]

L. M. DAVIS

Bureau of Markets, Washington, D. C.

The subject of field surveys and dairy marketing investigations as conducted by the Bureau of Markets, United States Department of Agriculture, is, to some extent, a comparatively new line of work. Although the terms "survey" and "investigation" imply the same character of work, the Bureau of Markets in its Dairy Section has recognized a distinction, and has adopted the use of the term "survey" when speaking of studies or investigations of producers' marketing problems, and the term "investigation" when the studies pertain to problems of market distribution. With this rather arbitrary distinction in mind, the various phases of field surveys and later those pertaining to marketing investigations will be discussed.

THE PURPOSE OF DAIRY MARKETING SURVEYS

It is generally recognized that the profitable production of dairy products is closely related to their efficient and economical marketing. The recent efforts of milk producers in many sections of the United States to improve their milk marketing conditions and methods have resulted in the organization of milk marketing associations for the purpose of pooling their product for sale. Some associations have provided facilities for manufacturing their milk or cream into butter, cheese, or other dairy products, while others have undertaken the ultimate distribu ion of market milk to consumers through the establishment and operation of a city mi k distributing plant.

The type of an organization which will best serve the d iry interests of a community, the marketing facilities which should

[1] Paper presented at the Dairy Marketing Conference held at Columbus, Ohio, October 23, 1917 during the National Dairy Show.

be provided, and the arrangements which should be made for the sale of the surplus product, are matters which are usually contingent upon local conditions and the markets which are available. A casual inquiry relative to the local conditions and the available market outlets is often an insufficient basis upon which to determine the type of organization or the facilities which should be employed. So important are these factors that a careful survey must be made of the marketing conditions existing both within the producing territory and in the markets where the products are to be sold before a definite decision can be reached regarding the best methods of solving a community's dairy marketing problem.

SCOPE OF DAIRY MARKETING SURVEYS

Whether a private individual, a corporation, or a cooperative organization of milk producers is to provide the marketing facilities and the marketing arrangements for the sale of a community's dairy product, it is essential that certain facts be established in order that the marketing conditions may be carefully analyzed and the success of the proposed marketing venture may be assured.

Obviously, the available supply of product to be marketed is an important factor to be determined, inasmuch as definite plans for manufacturing and marketing are dependent upon information regarding the amount to be handled. A second important factor to be determined is the disposition which is made of the milk or cream produced in the community or territory concerned, for under ordinary conditions it would be unwise to undertake the operation of a butter factory in a section where a sufficient supply of milk and cream could not be obtained to make a creamery a commercial success, or in a section where the production of market milk for city distribution had been highly developed. Likewise, other possible or competitive outlets of sale, such as cheese factories and condensories, should be considered. All of these are most important factors, because the first requirement of a dairy plant, no matter what the product handled may be, is

the supply of raw material. Many failures of cooperative organizations are traceable directly to the fact that an outside party whose interests were largely personal promoted the organization by selling stock in the needed building and equipment, and who, after getting his money, left the association with a plant full of equipment but located in a territory where the local production was too low to support the enterprise. If a survey shows that the available supply is insufficient to warrant the establishment of a local plant, the most logical action to take may be the organization of a cooperative association for the pooling and shipping of the product.

A very important and essential part of a dairy marketing survey where a cooperative dairy marketing organization is proposed is that of determining the spirit of cooperation among the producers and the presence of local leadership. Every local cooperative movement requires local leadership and without it the success of such an undertaking is more or less doubtful. Coordinate with the need of local leadership, there should be present among the producers or prospective organization members a spirit of true cooperation—a willingness to work together for mutual benefit. It is desirable, therefore, that the prospective members pledge not only to give financial assistance in securing the necessary capital, but also to furnish the product of their dairies to the association, as the latter is fully as important as the former for the successful operation of a cooperative marketing association. The possibility of obtaining satisfactory market outlets and the employment of a successful marketing system are other important factors to be considered, for frequently the type of organization, the capital invested and the method of business operation are dependent upon the methods of marketing to be employed.

Last, but not least, as an important part of a dairy marketing survey is a consideration of the practical and feasible form of business organization. Particularly is this important as it involves the methods of financing, the incorporation of the association, and the adoption of the proper form of constitution and by-laws governing business operations. The provisions of state

laws under which the organization may be incorporated as a capital stock, or a non-stock, non-profit organization, are governing features, limiting the membership in some states to actual farmers. Often it is desirable before determining upon any particular type of an organization to note the organization plans, form of incorporation and business methods of associations doing a similar business as that proposed, as suggestions may frequently be obtained which will be helpful in perfecting the proposed organization.

METHOD OF PROCEDURE IN CONDUCTING DAIRY MARKETING SURVEYS

The methods of procedure in conducting a dairy marketing survey will largely depend upon the purpose and extent of the survey and the available forces which may be used in conducting it. The local survey where a milk distributing plant is being considered must necessarily differ from a survey which embraces a wider territory. Various agencies, such as the county farm bureaus, certain trade and commercial organizations, or even public-spirited citizens may take the initiative in organizing the work, but the individual farmer must give a certain amount of assistance if the work is to be of maximum value. With the organization of county farm bureaus and the employment of county agricultural agents, a survey embracing a study of the dairy marketing problem in a county may be directed by the farm bureau agent. Such a survey is comparatively easy to make, for the farm bureau as an association is interested in improving agricultural conditions, of which the marketing of the farmer's products is not the least important. The county organization is usually composed of local community units, each having officers who are familiar with local conditions and who are acquainted with many of the farmers in the immediate community. Through this machinery, either by the use of a questionnaire or otherwise, it is possible to obtain the desired information from the leading farmers in every community in the county. Such surveys were made by the Bureau of Markets in Windham County, Connecticut, and Sussex County, New Jersey, and the

county agents in those counties who coöperated in the making of the surveys found the information which was secured of value to them. Dairy marketing surveys, however, need not be confined to single counties, for under the leadership and direction of the state authorities it is possible with the coöperation of the various county farm bureaus in the state to coördinate the separate county reports and summarize conditions for the entire state. Such a survey was made by the Bureau of Markets in coöperation with the Extension Division of the New Hampshire State College in the early part of this year. A report of this survey was published in July, 1917, as Extension Bulletin No. 8, and persons interested in securing copies of the report may do so by addressing the Extension Division, New Hampshire State College, Durham, New Hampshire. In this publication consideration is first given to the extent of dairy development and the natural conditions which favored the industry in that state. Then the present trend of agriculture is considered, with a discussion of the factors which have lent their influence in reducing dairy production. The facilities, methods and costs of transporting milk to the larger city markets are treated in connection with milk marketing contracts and prices. The dairy and creamery butter industries in the state are reviewed in connection with the possibilities of developing local markets. The opportunities as well as some of the advantages of coöperative organization of milk producers are pointed out as they relate particularly to existing dairy conditions. No attempt is made in this publication to offer definite suggestions as to how needed improvements should be undertaken, the sole purpose being to present fundamental facts regarding conditions which were found to exist. The summary made mentions the following factors as having had an influence upon the past development of the dairy industry in New Hampshire:

1. The use of scrub bulls or bulls of the beef breeds which have been generally unprofitable for specialized dairy purposes.

2. The failure of dairy farmers to give attention to the improvement of their herds, particularly along lines of more economical production.

3. The general development of markets for whole milk, which made the conditions for the rearing of dairy stock less favorable.

4. The uncertainty surrounding the making of contracts for the sale of whole milk caused by the systems employed in the past.

5. The monopolistic conditions afforded by the leased-car system of transportation which made rather prohibitory the shipment direct to city customers of milk or sweet cream by country organizations of producers operating their own plants.

6. The supplying of the summer boarder trade which encouraged summer rather than winter dairying as the prevailing system, with the result that dairying often became a side line rather than a regular or major phase of the farming operations.

7. The inability of the farmer to compete with the manufacturing industries in the employment of labor.

8. The lack of community interest in the permanent solution of the dairy marketing problems, as well as other agricultural problems.

9. The failure of the state to assume fully its responsibilities in affording to the dairy farmers advice and assistance in improving dairy marketing conditions and methods.

State dairy marketing surveys are now being undertaken in Vermont and in Colorado, where state marketing agents are stationed. A number of other states where marketing agents are located have already recognized the importance of their dairy marketing problems, although no systematic work in the nature of a survey has been undertaken.

VALUE OF DAIRY MARKETING SURVEYS

Perhaps the greatest value following the making of a dairy marketing survey lies in the use of the information which is assembled regarding the local marketing situation as it is applied toward improving marketing conditions. It is obvious that information thus gathered is indispensable to the local producers who may be contemplating the forming of a marketing organization, but it may likewise work to their advantage where

such an undertaking is not being considered, for the reason that the more the seller of a product knows regarding the marketing of the product, the more apt he is to obtain the highest market prices. Surveys are highly essential where milk producers are considering the advisability of establishing a creamery, cheese factory, distributing plant, or other dairy marketing organization, and when properly made should also result in creating an interest in the proposed new method of marketing, and serve to strengthen support in it. In a measure, they tend to insure the success of the dairy marketing organization formed as the result of the survey made.

A second advantage is that they create interest in local agricultural development. In almost any community weak points in the system of farming, and particularly marketing, may be found. If these weaknesses can be revealed to the farmers through a survey in which they themselves have had a part, an interest in eliminating these weaknesses, which are usually unprofitable methods and practices, may be developed. The needed improvements may consist of the more extensive growing of certain crops, the keeping of dairy herd production records, or the breeding of more profitable dairy stock. Dairy surveys may also serve to bring dairy farmers to a realization of their common interests, and the coöperative relation thus developed may prove to be of mutual benefit in a business or social way.

The greatest value of a dairy survey, however, lies in the carrying out of the conclusions reached and the deductions made as the result of an analysis of the data and information secured. With a knowledge of all the points embraced in a dairy survey, it is possible to decide with some degree of assurance as to how conditions may be improved, whether it is advisable for the farmers to coöperatively organize and if so, whether the association to be formed should simply maintain a selling agency or whether it should provide facilities for handling and preparing their dairy products for market. Specific data and information is essential to an intelligent understanding and the solution of dairy marketing problems, and it is the purpose of dairy marketing surveys to furnish such information. When dairy

farmers join in an organized effort to make their business more profitable, not altogether through merely securing higher prices under existing conditions, but by ascertaining whether they are supplying the most profitable markets with their product, and if not, learning where such a market is and what such a market wants as to quantity and quality, then furnishing both, the primary purpose of the dairy marketing survey will have been accomplished.

DAIRY MARKETING INVESTIGATIONS

As previously stated, the term "dairy marketing investigations" is used by the Bureau with reference to studies pertaining to problems of market distribution, and includes such phases of dairy marketing as the methods and costs of preparing dairy products for market; facilities for and cost of transporting and storing dairy products; market quotations and quotation systems for dairy products; market requirements; market conditions; marketing agencies; marketing systems and methods and expenses of marketing and distributing dairy products and dairy substitutes; the relation of cost and selling price of dairy products to their quality, grade, or classification and market quotation; the relation of supply, demand, and price of dairy substitutes to the supply, demand, and price of dairy products and vice versa; the channels of trade for marketing; the basis of trading; the relation of the supply of the various grades to market prices and quotations; the effect of import and export trade in dairy products and dairy substitutes upon market conditions, market quotations and prices; and economic factors which influence the demand and supply, as well as the market value of dairy products. All investigations of the various phases of the marketing and distributing of dairy products made by the Bureau are conducted in accordance with general outlines which have been previously formulated and which include, in as much detail as possible, the various important points which should be embraced within the investigation.

In connection with the drafting of an outline of an investigation, a plan of procedure to be followed in securing the desired

data and information is also formulated. With a written outline of the investigation and the procedure to be followed definitely agreed upon, it is possible in conducting marketing investigations to secure the essential data and information desired without loss of time or effort in conducting the work. In accordance with this plan, the Bureau of Markets has completed a number of dairy marketing investigations and has published reports covering a number of them. Among those investigations which have been made and reports issued, the following may be mentioned: An investigation of the markets for creamery butter in the Southern States and an investigation of the marketing of creamery butter in the United States. A report of the former investigation is contained in Circular No. 66 of the Office of the Secretary, entitled: "Suggestions for the Manufacture and Marketing of Creamery Butter in the South;" and a report of the latter investigation is contained in Department Bulletin No. 456, entitled: "Marketing Creamery Butter." Other investigations which have been made, but reports of which have not been published, include an investigation of the marketing of cheese in the United States and Canada, an investigation of milk marketing at Detroit, Michigan; an investigation of the marketing practices of the creameries of Wisconsin and Minnesota; an investigation of the relation of quality to price in the marketing of creamery butter; an investigation of milk marketing in New York State; and a general investigation of the marketing of milk in the United States. Besides these specific investigations, various other minor investigations of different phases of dairy marketing have been included in the investigational work of the Bureau. What is believed will be a most valuable bulletin and which deals with the organization, construction and operation of country milk stations, has been prepared for publication in coöperation with the New York State College of Agriculture.

Importance and value of dairy marketing investigations. As the purpose of dairy marketing surveys is primarily that of furnishing the necessary information for an analysis and a better understanding of producers' marketing problems, so dairy marketing investigations have for their object the analysis of dairy marketing and

distributing methods and conditions. The present methods of marketing and distributing dairy products have been developed largely to meet the needs of certain marketing conditions, and the fact that these marketing conditions as well as methods employed are steadily undergoing a process of evolution and change suggests that they are not necessarily the most efficient and economical. There is need, therefore, for a great deal of investigational work in dairy marketing, not only by the federal government, but by others in order that the existing methods be studied in the light of existing conditions, and that suggestions may be offered and measures taken to effect an improvement in the present systems whereby the costs of marketing and distributing may be reduced.

The activities of the Bureau of Markets relating to the marketing of dairy products have been in progress approximately three years, and while it has been impossible during this time to establish very many concrete results, the work has progressed to the point where definite plans have been made for increased activities in the future. With adequate appropriations to carry on the work, it is hoped that through the field surveys, dairy marketing investigations and dairy extension activities of the bureau, constructive suggestions may be offered and progress may be made in the solution of some of the dairy marketing problems in the United States.

ABSTRACTS AND REVIEWS OF DAIRY LITERATURE

Dairy Cattle Feeding and Management. C. W. LARSON AND FRED S. PUTNEY. New York, John Wiley & Sons, 1917.

A valuable service has been rendered dairy instructors and students as well as others interested in the feeding, care and management of dairy cattle in the publication of this thorough and up-to-date treatise. The book is prepared in a very attractive form being printed on paper of excellent quality which renders very clear and distinct not only the text but the decidedly helpful illustrations which have been carefully chosen to enhance the value of the textual material. The subject matter is conveniently divided into lectures and a full list of references is appended to each.

Before taking up the practical phases of feeding, the authors discuss in detail the principles of nutrition of dairy cattle, including digestion and metabolism, and outline briefly the development of feeding standards. Modern methods of balancing rations are treated thoroughly as well as the selection of feeds. A table of analyses of feeding stuffs conveniently arranged for ready reference is contained in the appendix. The influence of recent investigations in animal nutrition on feeding problems has not been overlooked.

The feeding and care of the young stock and herd sire are thoroughly treated, together with the general management of the herd, fitting dairy animals for show and the principles of breeding.

Some features of especial interest and value which hitherto have had but little attention in a text book dealing with milk production, are found in the latter part of the book. One of these is the lecture dealing with the feeding and management of cows during advanced registry tests. Another is the inclusion of a set of practicums which will greatly aid instructors in preparing laboratory exercises. The most valuable feature, perhaps, is the presentation of the principles and methods used in determining the costs of milk production. In view of the increasing interest in this subject, this discussion is, indeed, opportune.—W. B. N.

Productive Dairying. R. M. WASHBURN. Philadelphia, Pa., J. B. Lippincott Company.

In this book which is intended largely for use as a text book in sec-

ondary schools and as a handbook of information for students and farmers, the author presents in an attractive and logical manner a wealth of material covering the productive phases of dairying.

After discussing in the introductory chapters some of the advantages and benefits of dairy farming, the history, characteristics and type of the various dairy breeds are then fully treated. The practical phases of the care, feeding and management of the dairy herd, the approved methods to be followed in the production and handling of clean milk, together with the standards and rules for the production and distribution of certified milk are treated in a masterly way.

The author does not confine himself strictly to those phases of dairying dealing with the production of milk, but includes a discussion of the manufacture of various dairy products on the farm, the disposition and standards for market milk, and not least in importance by any means, the food value of milk.

A list of questions, which will aid the student in reviewing the subject, is appended to each chapter.—W. B. N.

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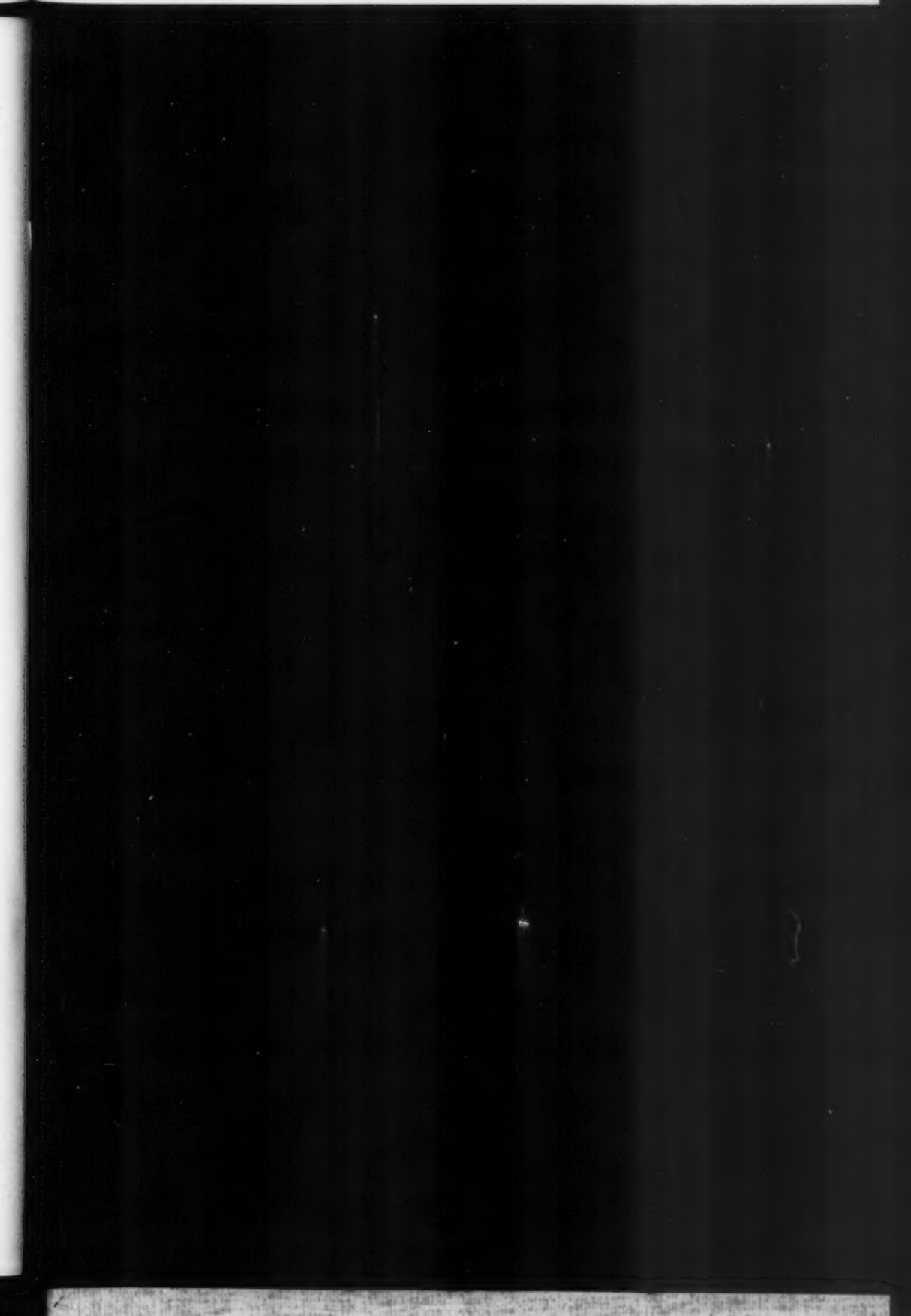

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